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Response of Guinea, Pangola, and Coastal Bermuda Grasses To Different Nitrogen Fertilization Levels Under Irrigation in The Lajas Valley of Puerto Rico

L. Rivera Brenes, J. Torres Más, and J. A. Arroyo[1]

INTRODUCTION

The Lajas Valley comprises around 35,000 acres of land on the southwest corner of the Island of Puerto Rico. Most of the land is in range pasture and sugarcane. The rainfall varies from 35 to 60 inches annually with a long dry period from October to May. An irrigation project has been under way there and by the end of 1959 around 12,000 acres were already under irrigation.

Foreseeing the impact that water for irrigation was to have on the agricultural pattern of the Valley, an experiment was outlined to determine the effects of fertilizer on Guinea grass, the prevailing one in the area, as well as on Pangola and Coastal Bermuda, both of which exhibit good potentialities.

Fertilization of pasture grasses is very seldom practiced in the Valley, because it is believed that beneficial fertilizer effects are apparently lost due to the prolonged dry periods. The senior author had performed grazing experiments with heavy fertilization and no irrigation. His results gave no support to this belief (*5*).[2]

With water for irrigation available in the Valley it is assumed that pasture-management practices will become more efficient and intensified. Information on pasture-management practices under irrigation was lacking.

A report on the first observations made on response to nitrogen applications under irrigation in the Lajas Valley follows.

[1] Animal Husbandman, Head of Animal Husbandry Department; Research Assistant at the Lajas Substation; and Assistant Chemist at the Animal Husbandry Department, respectively, Agricultural Experiment Station, University of Puerto Rico, Río Piedras, P.R.

[2] Italic numbers in parentheses refer to Literature Cited 145–6.

PROCEDURE

The experiment was performed in Santa Isabel clay, one of the major soil types of the Valley. This soil is similar to Aguirre clay, to Guánica clay, and to Fraternidad (*3*). There is little risk in considering these soils as of practically the same value for pasture production.

The experimental design was a split-plot one in which the grasses were tested in the large plots and the fertilizer levels in the small plots (20 x 20 feet). The grasses under test were Guinea (*Panicum maximum*), Pangola (*Digitaria decumbens*), and Coastal Bermuda (*Cynodon dactylon*). The nitrogen levels were 200, 400, 800, and 1,200 pounds of N per year, apportioned in six applications at 60-day intervals. Four replications for grasses were used. The grasses were cut every 60 days. A total of 12 cuttings were made.

The following data were taken: 1, Yields of green roughage and dry matter per acre per year; 2, hay yields per acre per year, standardized to 20-percent moisture; 3, gross-energy values; 4, percentage protein and total protein per acre per year; 5, leaf-to-stem ratio.

Plot yields were weighed carefully and samples were obtained for dry-matter, crude-protein, and gross-energy determinations. Chemical analyses were made according to the Official Methods and gross-energy determinations were made in a Parr oxygen-bomb calorimeter.

During the first year of the experiment hay was made artificially from all the grasses. An all-crop dryer was used for that purpose. Field-cured hay was made also. Hay yields were standarized to 20-percent moisture for comparison. Uncontrolled palatability tests were made with the hays using goats and cows. Not enough hay was produced from the plots for a controlled experiment.

Irrigation was applied whenever needed, as indicated by a tensiometer installed in the center of the plots. Special perforated pipes were used and water applications equivalent to 2 inches per acre per irrigation were made.

For supplementary information, samples of soil from each plot were taken, at 8 to 12 inches of depth at the beginning and at the end of the 2-year period, to ascertain the effects of the application of large amounts of ammonium sulfate on soil acidity.

The leaf-to-stem ratio was determined by gathering a bunch of more than 100 culms from each plot at harvesttime; then, the leaves and stems were separated by hand.

Treatments were checked separately.

The data—statistically analyzed and measured—were designed to provide information on:

1, Effects of nitrogen level on yield of green roughage and of dry matter of hay, on gross energy, and on percentage of protein and total protein per

acre; 2, seasonal effects on yield; 3, comparison of the grasses in their response to the different N treatments.

LITERATURE REVIEW

The use of fertilizer nitrogen to improve both the quality and quantity of forage grasses is recommended worldwide, as attested by the very large amount of literature on the subject issued in agricultural journals during the past 10 years.

In Puerto Rico, the Agricultural Experiment Station and the Agricultural Research Service have been jointly working to determine the response of the principal grasses to different nitrogen fertilization levels in the various climatic regions of the Island.

Rodríguez (*6*), working in the north humid region, found that 200 pounds of nitrogen a year more than doubled the yield of Guinea grass as compared to the no-nitrogen application, when a harvest interval of about 60 days was used. Similar results were obtained with Napier and Pará grasses.

Rivera Brenes (*4*) studied the same three grasses in the same north humid section in a Vega Alta clay loam of pH 5.3, and a Sabana Seca clay, of pH 5.8, with one application of 40 pounds of nitrogen and no liming. The grasses were harvested at 40, 90, and 120 days of age. Yearly productions for Guinea grass of 19,800, 14,000, and 13,740 pounds of dry matter per acre for the 40, 90, and 120 days of age, respectively, were estimated.

Vicente and Figarella (*7*) found that, in the semiarid region of Coamo on a nonirrigable Coamo clay, the application of 100 pounds of nitrogen per acre to Guinea grass toward the end of the wet season markedly increased the dry-matter yield from 3,555 to 5,520 pounds and protein from 238 to 486 pounds per acre. Heavier applications of nitrogen tended to increase protein yields and the protein content of the forage, but not the yields of dry matter.

Unpublished data of Smith and Vicente, cited by Vicente and Rivera Brenes *et al.* (*9*), show that the application of 300 pounds of nitrogen per acre per year markedly increased the yields of irrigated Guinea grass from 12,400 to 21,500 pounds of dry matter per acre. The quantity of irrigation water applied was not mentioned.

Little, Vicente, and Abruña (*2*) worked in the semiarid south section of Santa Isabel, in a San Antón sandy clay loam of pH 7.5. They tested five levels of nitrogen fertilization (0, 200, 400, 800, 1,600 pounds of N per acre per year) under irrigation for 2 years, and reported the following results: Grasses cut while 30 to 60 days old had dry-matter yields per acre of 37,000 to 59,000 for Napier, 16,000 to 43,000 for Guinea, and 7,000 to

20,000 pounds for Pangola. Percentages of protein varied from 7.7 to 11.4 for Napier, from 6.4 to 11.2 for Guinea, and from 6.5 to 12.6 for Pangola. Total protein in pounds per acre ranged from 2,893 to 6,751 for Napier, from 1,041 to 4,881 for Guinea, and from 474 to 2,642 for Pangola grass. The protein content of all grasses increased with the nitrogen level. They found that yields of Napier and Guinea grasses responded strongly to nitrogen applications up to 800 pounds per acre yearly, but Pangola responded strongly only to the 200-pound level. Heavy applications of ammonium sulfate affected soil pH as expected. The application of 800 pounds of nitrogen reduced the pH of the upper 6 inches of soil from 7.7 to 6.8; the application of 1,600 pounds of nitrogen per acre per year further reduced it to 5.2.

Vicente, Silva, and Figarella (*8*) worked at Río Piedras, in the north humid section of the Island, on the effect of nitrogen fertilization and frequency of cutting on the yield and composition of Napier, Guinea, and Pará grasses. Nitrogen fertilization levels of 0, 200, 400, 800, 1,200, 1,600, and 2,000 pounds per acre and harvest intervals of 40, 60, and 90 days were used. Soil was limed to about pH 7 and 300 pounds of P_2O_5 and 600 pounds of K_2O per acre were applied as "blanket additions."

The 1,600-pound level was not used for Napier, nor the 1,200-pound level for Guinea or Pará grasses. The Napier grass experiment was established in a Toa clay loam alluvial soil and the Guinea and Pará grasses experiments on a Fajardo clay, a deep red soil.

The findings reported were: Yields increased with harvest interval, but at 60 days, dry-matter yields per acre per year according to nitrogen level were from 15,000 to 46,000 for Napier grass, 10,000 to 34,000 for Guinea grass, and from 7,000 to 32,000 pounds for Pará grass. There was a rapid increase in yield for all grasses up to the 800-pounds-of-nitrogen treatment. The protein content of all grasses increased with nitrogen fertilization up to the highest level. For Napier from 6.5 to 13.8; for Guinea from 6.2 to 12.4; and for Pará from 6.4 to 12.1 percent.

A marked seasonal effect on yields was demonstrated in this work. There is a period of high production from April through August and a sharp decline occurs from then on. Results presented showed a tendency for yields to follow somewhat the rainfall pattern throughout the year.

The application of 800 pounds of nitrogen reduced the pH from 7.0 to 4.1 in the first 6 inches of soil in the Toa soil, and from 6.7 to 4.6 in the Fajardo clay.

RESULTS

Yields of green forage, dry matter, total protein, percentage of protein, and gross energy; pounds of dry matter per pound of nitrogen applied;

and cost per pound of dry matter according to nitrogen applied are presented in table 1 for the three grasses studied. Table 2 presents the data on hay yields per acre, standardized to 20-percent moisture.

TABLE 1.—*Yields per acre per year of green forage, dry matter, crude protein, and gross energy for Guinea, Pangola, and Coastal Bermuda grasses*[1]

Treatment No.	N per acre	Green forage	Dry matter	Protein[2]	Total protein	Dry matter per pound of N applied	Cost per pound of dry matter considering only cost per pound of N applied[3]	Gross energy
	Guinea grass							
	Pounds	*Tons*	*Pounds*	*Percent*	*Pounds*	*Pounds*	*Cents*	*Cal./gm.*
2	200	28.03	17,376.87	8.10	1,408.37	86.88	0.17	4.02
4	400	33.32	20,010.38	9.93	1,986.75	50.02	.30	4.02
8	800	36.24	21,527.88	12.94	2,786.38	26.91	.50	4.07
12	1,200	39.05	22,049.13	14.06	3,099.88	18.37	.80	4.03
	Pangola grass							
2	200	16.27	11,284.00	6.93	781.87	56.42	0.26	4.00
4	400	24.24	15,509.75	8.02	1,243.50	38.77	.39	4.02
8	800	34.63	19,896.37	11.09	2,206.00	24.56	.61	4.09
12	1,200	41.21	22,889.62	12.06	2,761.62	19.07	.78	4.10
	Coastal Bermuda grass							
2	200	14.33	10,946.38	7.20	788.00	54.73	0.27	4.23
4	400	15.24	14,874.75	8.33	1,239.75	37.18	.40	4.29
8	800	19.96	18,149.00	10.37	1,881.50	22.69	.66	4.35
12	1,200	24.08	22,240.13	11.30	2,512.25	18.53	.81	4.36

[1] Average of 2 years. Pounds of dry matter per pound of nitrogen applied and cost per pound of dry matter produced under the different nitrogen treatments.

[2] Percentage protein = average for 48 samples for each nitrogen level.

[3] Cost of 1 pound of N from ammonium sulfate = 15 cents.

The data for the 2 years of the experiment were analyzed statistically with the following results.

GUINEA GRASS

For yield of green forage from Guinea grass, treatment 12 was significantly better at the 1-percent level only than treatment 2. No significant difference was found between treatments 8, 4, and 2. At the 5-percent level

treatments 12 and 8 were significantly better than treatment 2. Analysis of variance expressed in hundredweights per acre for 2 years follows:

Treatment No.	*Treatment mean, green forage*	*Treatments outyielded at—*	
		1-percent level	*5-percent level*
12	1,561.96	2	2
8	1,449.51	—	2
4	1,333.45	—	—
2	1,121.33	—	—

$s_{\bar{x}}$ = 73.28; error d.f. = 9

Yields were low for Guinea grass at all levels of nitrogen fertilization. This low production may have been caused by several things, such as too much water of irrigation, slow drainage even if the water of irrigation was not excessive, water table too close to the roots, and needs for phosphorus, potash, and other elements. A detailed consideration of available data not presented here indicates that the low levels of available phosphorus and potash may have been the most important factors in this connection.

For dry-matter yields no difference was found between treatments at the 1-percent level, but at the 5-percent level treatment 12 was significantly better than treatment 2 only (fig. 1). Analysis of variance of dry matter yield in hundredweights per acre for 2 years follows:

Treatment No.	*Treatment mean, dry matter*	*Treatments outyielded—*	
		1-percent level	*5-percent level*
12	440.98	—	2
8	430.56	—	—
4	400.21	—	—
2	347.54	—	—

$s_{\bar{x}}$ = 21.14; error d.f. = 9

Guinea grass responded very well to the nitrogen applications in total protein per acre. Treatment 12 was significantly better than treatments 2 and 4 at the 1-percent level, but not significantly better than treatment 8. Treatment 8 was better than treatments 4 and 2, and treatment 4 better than treatment 2. Analysis of variance in hundredweights per acre for 2 years follows:

Treatment No.	*Treatment mean, total protein*	*Treatments outyielded at 1-percent level*
12	62.00	2, 4
8	55.73	2, 4
4	39.74	2
2	28.17	—

$s_{\bar{x}}$ = 2.19; error d.f. = 9

TABLE 2.—*Calculated hay yields per acre of the 3 grasses at different nitrogen levels adjusted to 20-percent moisture for purposes of comparison*

Grass	Nitrogen level[1]	Yield in tons per acre per year
Guinea	2	10.86
	4	12.50
	8	13.45
	12	13.78
Pangola	2	7.05
	4	6.69
	8	12.49
	12	14.30
Coastal Bermuda	2	6.84
	4	9.30
	8	11.68
	12	13.90

[1] See table 1 for explanation.

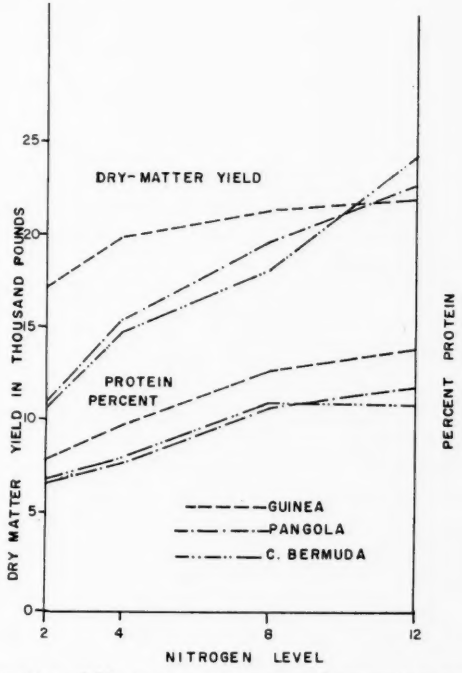

FIG. 1.—Dry-matter yield per acre per year and percentage protein content of Guinea, Pangola, and Coastal Bermuda grasses when grown at different nitrogen levels.

Hay was made from all the grasses under test as explained in Procedure. Because of the variability of the moisture left in the grasses the production of hay was calculated based on 20-percent moisture, table 2. For Guinea grass the yield of hay for treatment 12 was significantly better at the 5-percent level than that of the other treatments. No significant difference was found among the other treatments. Analysis of variance for hay in hundredweights per acre for 2 years follows:

Treatment No.	*Treatment mean, hay yield*	*Treatments outyielded at 5-percent level*
12	551.25	2
8	538.20	—
4	500.28	—
2	434.44	—

$s_{\bar{x}}$ = 26.43; error d.f. = 9

Analysis of variance for gross energy for Guinea grass follows:

Treatment No.	*Treatment mean*
12	4.07
8	4.04
4	4.07
2	4.02

$s_{\bar{x}}$ = 0.01806; error d.f. = 9

No significant difference in gross energy was found between treatments. Actually, utilizable energy has to be measured as digestible energy in digestion trials, but not enough roughage was produced to run a digestion trial for any of the grasses.

PANGOLA GRASS

Pangola grass responded very well to the different nitrogen levels. For yields of green forage treatment 12 was better at the 1-percent level than treatments 4 and 2, and at the 5-percent level than treatment 8. Treatment 8 was better than treatments 4 and 2 at the 1-percent level and treatment 4 better than treatment 2 at the 1-percent level. Analysis of variance in hundredweights per acre for 2 years follows:

Treatment No.	*Treatment mean, green, forage*	*Treatments outyielded at—*	
		1-percent level	*5-percent level*
12	1,648.48	2, 4	2, 4, 8
8	1,385.27	2, 4	2, 4
4	969.73	2	2
2	650.76	—	—

$s_{\bar{x}}$ = 69.90; error d.f. = 9

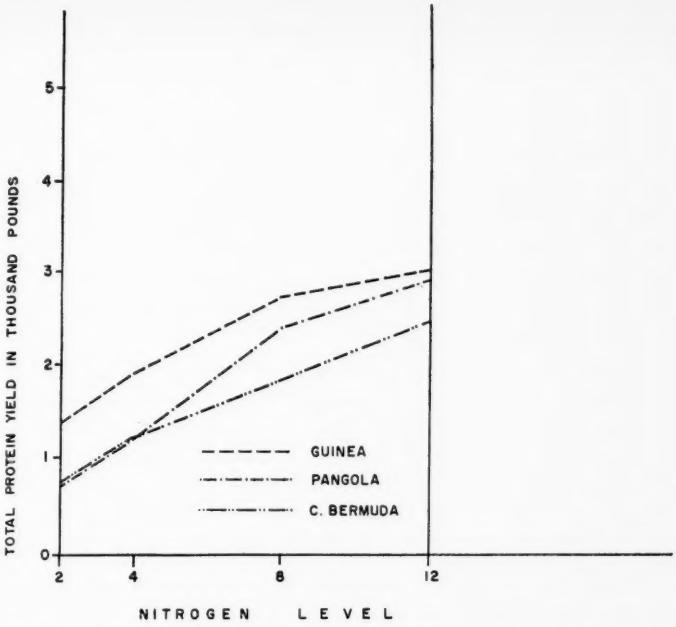

FIG. 2.—Total protein yields per acre per year of Guinea, Pangola, and Coastal Bermuda grasses as affected by nitrogen level.

Yields of dry matter had the same statistical differences as for green forage. Analysis of variance in hundredweights per acre for 2 years follows:

Treatment No.	*Treatment mean, dry matter*	*Treatments outyielded at—*	
		1-percent level	*5-percent level*
12	457.79	2, 4	2, 4, 8
8	397.93	2, 4	2, 4
4	310.20	2	2
2	225.68	—	—

$s_{\bar{x}}$ = 18.13; error d.f. = 9

Statistical analysis for total protein yield per acre demonstrated the following differences: Yields for treatment 12 were significantly higher than those of treatments 2, 4, and 8 at the 1-percent level; for treatment 8 they were significantly higher at the 1-percent level than for treatments 2 and 4, and for treatment 4 higher than for treatment 2 at the 1-percent level (fig. 2). Analysis of variance in hundredweights per acre for 2 years follows:

Treatment No.	*Treatment mean, total protein*	*Treatments outyielded at 1-percent level*
12	55.23	2, 4, 8
8	44.12	2, 4
4	24.87	2
2	15.64	—

$s_{\bar{x}}$ = 1.56; error d.f. = 9

Treatment 12 produced hay yields per acre higher at the 1-percent level than did treatments 2 and 4, but not better than did treatment 8. Yields under treatment 8 were significantly higher at the 1-percent level than for treatments 2 and 4, and for treatment 4 significantly higher, at the 1-percent level, than for treatment 2. Analysis of variance in hundredweights per acre for 2 years follows:

Treatment No.	*Treatment mean, hay yields per acre*	*Treatments outyielded at 1-percent level*
12	572.12	2, 4
8	499.52	2, 4
4	387.70	2
2	282.13	—

$s_{\bar{x}}$ = 22.92; error d.f. = 9

Some differences were found between treatments in gross energy in Pangola grass. Analysis of variance per gram of dry matter follows:

Treatment No.	*Treatment mean*	*Treatments outyielded at—*	
		1-percent level	*5-percent level*
12	4.10	2	2, 4
8	4.09	—	2, 4
4	4.02	—	—
2	4.00	—	—

$s_{\bar{x}}$ = 0.016; error d.f. = 9

COASTAL BERMUDA GRASS

Coastal Bermuda grass also responded to the different nitrogen levels, although not so well as Pangola. For yield of green forage, treatment 12 was significantly better at the 1-percent level than treatments 2 and 4, but no difference was found with treatment 8. Treatment 8 was significantly better at the 4-percent level than treatments 4 and 2. No difference was found between treatments 2 and 4. Analysis of variance for green forage in hundredweights per acre for 2 years follows:

Treatment No.	*Treatment mean, green forage*	*Treatments outyielded at—*	
		1-7ercent level	*5-percent level*
12	963.06	2, 4	2, 4
8	798.32	—	2, 4
4	609.62	—	—
2	573.17	—	—

$s_{\bar{x}}$ = 54.25; error d.f. = 9

In producing dry-matter yield per acre treatment 12 was significantly better than treatments 4 and 2 at the 1-percent level and than treatment 8 at the 5-percent level. Treatment 8 was better than treatment 2 at the 1-percent level, but not better than treatment 4. Treatment 4 was better than treatment 2 at the 5-percent level. Analysis of variance for yield of dry matter per acre for 2 years follows:

Treatment No.	*Treatment mean, dry matter*	*Treatments outyielded at—*	
		1-percent level	*5-percent level*
12	444.80	2, 4	2, 4, 8
8	362.98	2	2
4	297.50	—	2
2	218.93	—	—

$s_{\bar{x}}$ = 21.11 error d.f. = 9

For the production of total protein per acre Coastal Bermuda grass under treatment 12 was significantly higher than under treatments 8, 4, and 2 at the 1-percent level; treatment 8 was better at the 1-percent level than treatments 4 and 2; and treatment 4 was better than treatment 2 at the 5-percent level. Analysis of variance for total protein per acre for 2 years follows:

Treatment No.	*Treatment mean, total protein per acre*	*Treatments outyielded at—*	
		1-percent level	*5-percent level*
12	50.25	2, 4, 8	2, 4, 8
8	37.63	2, 4	2, 4
4	24.79	—	2
2	15.76	—	—

$s_{\bar{x}}$ = 2.11; error d.f. = 9

For hay yield treatment 12 was better than treatments 2 and 4 at the 1-percent level and better than treatment 8 at the 5-percent level. Treatment 8 was better than treatment 2, but not better than treatment 4 at the 1-percent level. Treatment 4 was better than treatment 2 at the 5-percent level. The analysis of variance for hay yield per acre for the 2 years follows:

Treatment No.	*Treatment mean, hay yield*	*Treatment outyielded at—*	
		1-percent level	*5-percent level*
12	556.02	2, 4	2, 4, 8
8	467.35	2	2
4	372.03	—	2
2	273.68	—	—

$s_{\bar{x}}$ = 27.73; error d.f. = 9

For the production of gross energy treatment 12 was significantly better than treatment 2, but not better than treatments 4 and 8 at the 5-percent

level. Treatment 8 was better than treatment 2 at the 5-percent level, but not better than treatment 4. No significant difference was found between treatments 4 and 2. The analysis of variance for gross energy at the different nitrogen fertilization levels follows:

Treatment No.	*Treatment mean, gross energy*	*Treatments outyielded at—*	
		1-percent level	*5-percent level*
12	4.36	2	2
8	4.35	2	2
4	4.29	—	—
2	4.23	—	—

$s_{\bar{x}}$ = 0.0272; error d.f. = 9

For the production of gross energy treatment 12 was significantly better than treatment 2 at the 5-percent level, but not better than treatments 4 and 8. Treatment 8 was better than treatment 2 at the 5-percent level, but not better than treatment 4. No significant difference was found between treatments 4 and 2.

The grasses were compared by adding the yields of the four treatments for the 2 years and submitted to an analysis of variance (table 3).

In spite of the fact that its yields are considered low, as said before, Guinea grass outyielded the other two in all other aspects but gross energy. Pangola and Coastal Bermuda grasses were similar in yields except for gross energy, in which Coastal Bermuda also excelled Guinea grass.

Figure 1 shows the response of the three grasses to the different nitrogen levels as to yield of dry matter and percentage protein. Figure 2 shows the response of the grasses as to total protein yields under the different nitrogen levels.

The data on rainfall and amount of water of irrigation are presented in table 4 and the pH values found before and after 2 years of experiment are given in table 5. The pH values were taken in only two plots as only a check was sought on the possibility of any drastic change due to ammonium sulfate fertilization. Apparently 2 years were not enough to bring drastic changes in this soil under these fertilizing schedules.

The factors previously mentioned as adversely influencing the Guinea grass yields apparently affected more acutely the results at the high-nitrogen levels; the low-nitrogen levels of 200 and 400 pounds per acre produced yields which were higher than those obtained by Little *et al.* (*2*) at Aguirre and Vicente *et al.* (*8*) at Río Piedras.

DISCUSSION

PANGOLA GRASS

Yields of Pangola grass were good and compared favorably with yields obtained by others (see Literature Review). Higher yields could probably

TABLE 3.—*Comparison of results with Guinea, Pangola, and Coastal Bermuda grasses with analyses of variance to show differences among them*

Grasses, factors compared $s_{\bar{x}}$, and error d.f.	Adjusted mean yields	Results at 1-percent level	Results at 5-percent level
Individual treatments			
	Cwt./A.		
Green matter			
Guinea	5,652.10	Guinea better than Bermuda	Guinea better than Bermuda and Pangola, and Pangola better than Bermuda
Pangola	4,426.48		
Bermuda	2,986.06		
$s_{\bar{x}}$ = 224.68, error d.f. = 4			
Dry matter			
Guinea	1,664.62		Guinea better than Pangola and Bermuda
Bermuda	1,349.77		
Pangola	1,320.70		
$s_{\bar{x}}$ = 51.39, error d.f. = 4			
Hay 20-percent moisture			
Guinea	2,084.57		Do.
Bermuda	1,701.81		
Pangola	1,648.44		
$s_{\bar{x}}$ = 64.40, error d.f. = 4			
Total protein			
Guinea	188.36	Guinea better than Bermuda and Pangola	Do.
Pangola	135.14		
Bermuda	130.43		
$s_{\bar{x}}$ = 3.70, error d.f. = 4			
All treatments added			
Grasses, factors compared, $s_{\bar{x}}$, and error	Adjusted mean yields	Results at 1-percent level	Results at 5-per cent level
	Cal./gm.		
Gross energy			
Bermuda	17.26	Bermuda better than Pangola and Guinea	Bermuda better than Pangola and Guinea
Guinea	16.20		
Pangola	16.13		
$s_{\bar{x}}$ = 0.0103, error d.f. = 4			

TABLE 4.—*Rainfall and water-of-irrigation (inches) data from October 1956 to September 1958 inclusive, by months*

Month	1956		1957		1958	
	Rainfall	Irrigation	Rainfall	Irrigation	Rainfall	Irrigation
October	10.45	—				
November	6.08	2.0				
December	3.38	—				
January			2.12	4.0	2.97	2.0
February			.85	2.0	.25	2.0
March			.31	4.0	.31	4.0
April			1.20	2.0	4.62	2.0
May			1.40	2.0	2.97	2.0
June			.86	4.0	4.52	2.0
July			.36	6.0	6.81	—
August			5.27	2.0	5.80	—
September			10.43	—	9.48	—
October			6.18	—		
November			2.83	2.0		
December			3.50	2.0		
Total	19.91	2.0	35.31	30.00	37.55	18.0
Total water	21.91		65.31		55.55	

TABLE 5.—*pH values prior to the start of the experiment and after 2 years of experiment according to nitrogen level for one Pangola and Guinea grass plot*

Soil sample No.	Values prior to experiment		Grass and plot No.	Values 2 years after		
	Depth in inches	pH		N level	Depth in inches	pH
U 285 x	0–8	6.7	Guinea 24	2	0–8	8.0
	8–24	7.9		2	8–15	7.4
				4	0–8	7.6
V 285	0–8	6.5		4	8–15	7.8
	8–24	7.7		8	0–8	7.0
				8	8–15	7.0
				12	0–8	5.8
				12	8–15	6.9
V 286	0–8	7.8	Pangola 17	2	0–8	7.6
	8–24	7.8		2	8–15	7.3
				4	0–8	7.8
				4	8–15	8.4
				8	0–8	6.2
				8	8–15	6.9
				12	0–8	5.7
				12	8–15	6.9

have been obtained had phosphorus and potash been used together with nitrogen. Present experiments in the same plots hint toward that assumption.

Aphids presented no problem under the irrigation and cutting-interval management system used.

Pangola grass is very easy to establish and permits very little competition from weeds. The stands reach cutting or grazing condition in 3 to 6 months. Except for one or two weedings a year, it needs very little care.

Although lower in yield than Guinea, it is believed that Pangola will find acceptance in the Lajas Valley under irrigation because of its easy management, its resistance to rough treatment, and its palatability, aggressiveness, and fast recovery period.

The results presented demonstrate that Pangola responds very well to increasing nitrogen applications; further research is needed to determine the proper quantity to recommend for Lajas Valley conditions.

COASTAL BERMUDA GRASS

Coastal Bermuda grass was similar in yield to, and better in dry-matter content and gross energy than Pangola. However, the following factors make Coastal Bermuda impractical and uneconomical under Lajas Valle conditions:

1. It takes too long to cover the ground and be ready to cut or graze.
2. It is not as aggressive as Pangola and weeds compete favorably with it. Large expenditures of time and money had to be made to keep the plots free of weeds and in good condition.

HAY

Hay made from the three grasses was tested for palatability with goats and cows. The best hay yields per pound of nitrogen applied were obtained from Guinea grass at the lower nitrogen levels (table 2). However, it was very poorly accepted by the animals.

Artificially cured hay, using an all-crop dryer, and field-cured hay were made. The stem of Guinea grass is relatively thick and takes too long to dry conveniently, requiring 4 or 5 days of good sunshine for field curing and 2 to 3 days on the dryer, after wilting for a few hours in the field.

It took so long for the moisture in the stems to reach a satisfactory level that the leaves were practically without moisture and almost completely bleached. The hay was very coarse and brittle. The use of a crusher might improve the quality, but there is no certainty that this would improve the palatability.

Coastal Bermuda produces a very good palatable hay. Field-cured hay takes less than 2 good-weather days to make. Artificially cured hay re-

quires from 8 to 10 hours in the dryer after being wilted for a few hours in the field. This grass contains much more dry matter per pound of green material than either Guinea or Pangola, a fact that cuts the time needed to reduce the moisture properly.

Coastal Bermuda grass produces a very palatable hay; both goats and cows relish it. Pangola grass also produces good, very palatable hay, similar to Coastal Bermuda hay, although of a little darker color.

Pangola hay, either for farm use or for commercial use by race horses and calves, can be produced in Lajas Valley by the proper use of dryers. Actually, the importation of timothy hay and a small amount of alfalfa hay runs to over $1,000,000 a year, with costs of from $70 to $80 a ton at the farm.

PERCENTAGE PROTEIN CONTENT

Pangola and Coastal Bermuda responded similarly in percentage protein content to the level of nitrogen applied. Guinea grass had a little higher protein content, probably due to a larger proportion of leaves to stems (*4*).

Table 1 shows the pounds of dry matter produced and the cost thereof per pound of nitrogen applied, according to nitrogen level. Dry matter can be produced cheaper with the lower levels of nitrogen application. The yield data seem to be in line with what should be expected from the law of diminishing returns.

Experiments are under way to seek additional information on this point. Results show that Pangola responded to all levels of nitrogen applications, 1,200 pounds being better than 800, 400, and 200; 800 pounds better than 400 and 200; and 400 better than the 200 pounds.

Coastal Bermuda acts similarly, except that no difference was found between the 400- and 800-pound nitrogen levels.

Fertilizer is a costly item in pasture management in Puerto Rico. As we do not have good legumes and must strive for top production, both in quality and in quantity, large quantities of fertilizer materials must be applied. That is one of the reasons it is so important to determine the economic amounts to recommend. In the meantime, quantities between 300 and 400 pounds of nitrogen per acre can be used, depending on the fertility of the soil.

Table 6 presents the calculated carrying capacities of the grasses under the different nitrogen treatments tested and using the factors of standard cow-days for dairy and beef cows.

The estimated average weight for dairy cows in Puerto Rico is about 900 pounds (equivalent to 350 pounds, or 14 *arrobas* of beef). Assuming an average daily consumption of 15 pounds of dry matter (corresponding to 7.5 pounds of digestible nutrients) to be enough for maintenance, these

grasses will carry the number of cows per acre that appear in table 7, according to treatment. See table 1 for yields of dry matter.

These figures are presented for comparison only and allowance must be made for the kind of cattle on a particular farm, lactating cows, pregnant cows, and growing stock. For beef cows calculations should include both cow and calf.

TABLE 6.—*Carrying capacity of Pangola, Coastal Bermuda, and Guinea grasses, assuming 50-percent T.D.N. in the dry matter and that all the forages produced are consumed*

Grass	Average T.D.N. yield per acre per day according to N level under treatment No.—				Dairy cow (16 pounds of T.D.N. per day)[1] under treatment No.—				Beef cow (12 pounds of T.D.N. per day)[1] under treatment No.—			
	2	4	8	12	2	4	8	12	2	4	8	12
Pangola	15.5	21.2	27.2	31.5	0.97	1.33	1.70	1.97	1.29	1.97	2.27	2.63
Coastal Bermuda	14.99	20.37	24.86	30.46	.94	1.27	1.55	1.90	1.25	1.70	2.07	2.54
Guinea	23.8	27.41	29.49	30.20	1.49	1.71	1.84	1.89	1.98	2.28	2.46	2.52

[1] Standard cow-days.

TABLE 7.—*Carrying capacity of the 3 grasses assuming a 900-pound cow and 15 pounds of dry-matter consumption daily*

Grass	Number of cows under treatment No.—			
	2	4	8	12
Pangola	2.00	2.83	3.67	4.18
Coastal Bermuda	2.00	2.73	3.33	4.00
Guinea	3.20	3.67	3.93	4.00

SEASONAL VARIATION

A marked seasonal variation in yield was observed by Vicente *et al.* working on Napier, Pará, and Guinea grasses in the north humid section of the Island (*8*) with high production from April through August, and a sharp decline from then on.

A similar seasonal variation was observed in the present work. The high production starting in March attained a peak in September, followed by a sharp decline from then on (figs. 3, 4, and 5.) Statistical analysis of the data shows that this seasonal variation is cyclic. This finding is very important both for proper management of the grasses and feeding the cattle.

In the dry southwestern section of the Island, where the available water was controlled by irrigation, it was not possible to equate yields throughout

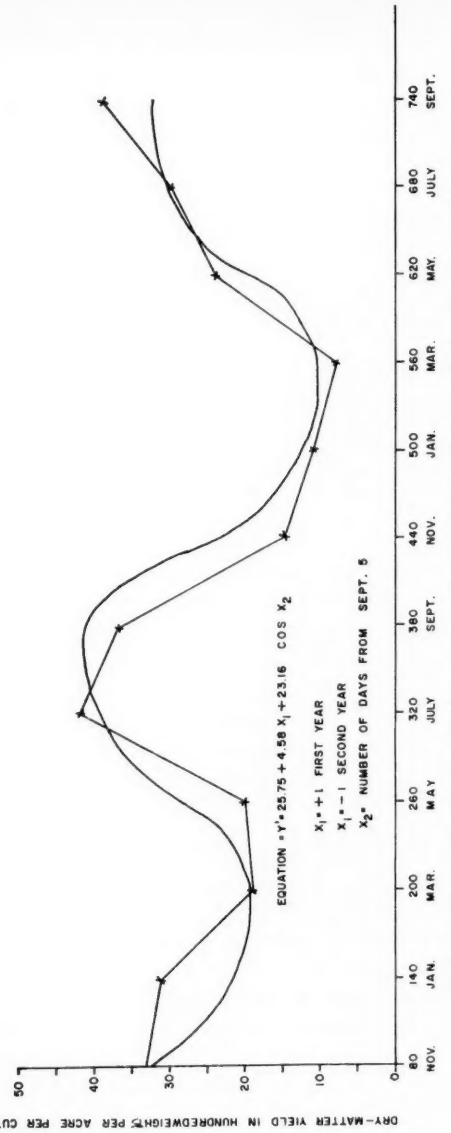

FIG. 3.—Seasonal variation in dry-matter content of Pangola grass during 2-year experiment.

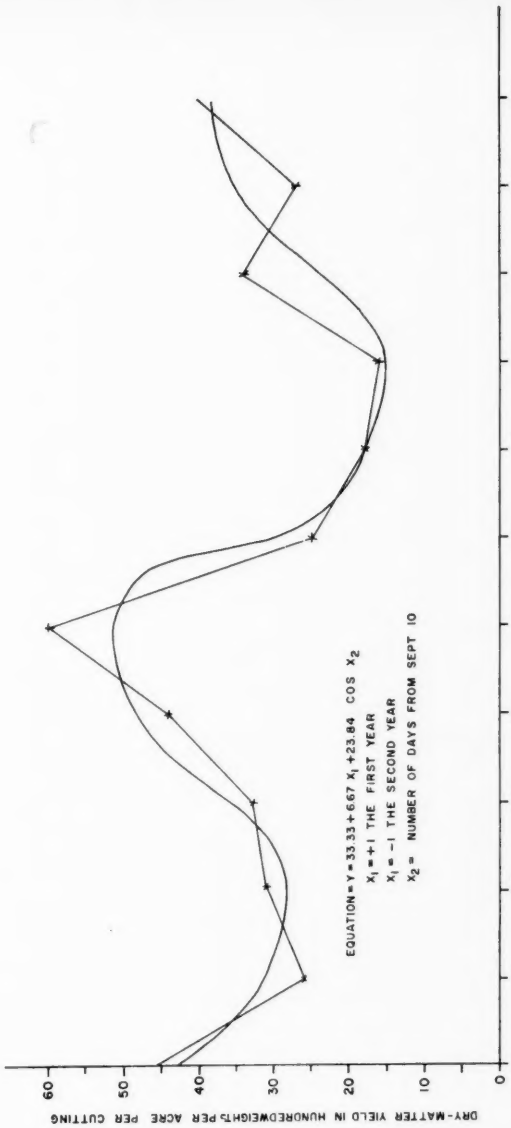

FIG. 4.—Seasonal variation in dry-matter content of Guinea grass during 2-year experiment.

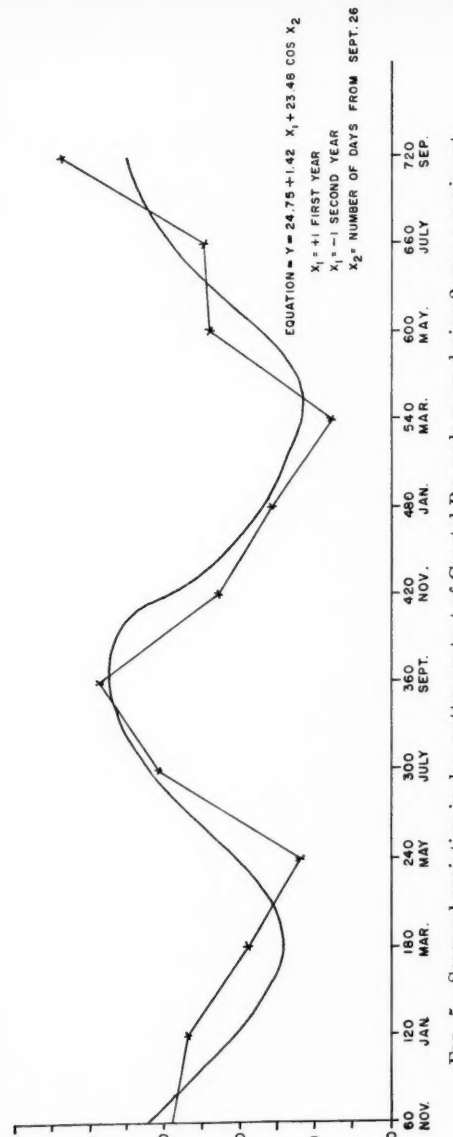

FIG. 5.—Seasonal variation in dry-matter content of Coastal Bermuda grass during 2-year experiment.

the year. The same holds true in the north humid section, which has a period of low production from November to February or March, when days are short and temperatures low.

In the north humid section it is probably more economical to ensile the excess roughage produced during May through September than to establish an irrigation system for use during the period of slow growth. In the Southwest, where dry periods are long and the amount of water during the rainy season uncertain and poorly distributed, irrigation of pastures is necessary.

There is a marked annual variation in yields of Pangola and Guinea grasses.

TABLE 8.—*Average dry-matter yields (pounds) for the first- and second-year harvests of the 3 grasses*

Grass	First year, average of 6 cuttings	Second year, average of 6 cuttings
Guinea	4,000	2,670
Pangola	3,051	2,118
Coastal Bermuda	2,625	2,331

TABLE 9.—*Average percentages of leaves and stems for the 3 grasses according to nitrogen level*[1]

Grass	Results at nitrogen level indicated—							
	200 lb.		400 lb.		800 lb.		1,200 lb.	
	Stem	Leaves	Stem	Leaves	Stem	Leaves	Stem	Leaves
Guinea	28.44	71.56	26.65	73.35	29.94	70.06	29.22	70.78
Pangola	67.09	32.91	66.84	33.16	67.49	32.51	64.96	35.04
Coastal Bermuda	48.24	51.76	50.24	49.76	48.65	51.35	49.98	50.02

[1] Average of 9 samples under each treatment.

Much better yields were obtained the first year than the second. Coastal Bermuda was more uniform in production from one year to the other.

Table 8 presents the average yields of dry matter for the first and second six cuttings corresponding to the first and second year for the three grasses. The effects of year, cutting, and cutting interval all have to be determined. Some of these grasses are best adapted only for grazing, and frequent cuttings affect the life of the stand. An experiment now going on in the same plots, to last 4 years, will probably shed additional information on some of these questions.

The leaf and stem percentages of the grasses are presented in table 9. The nitrogen treatments did not appreciably affect these percentages for any of the grasses.

Guinea grass proved to be superior in leaf:stem ratio to Pangola and Coastal Bermuda. This was found previously by Rivera Brenes (*4*) when Guinea grass was compared with Napier and Pará grasses. Coastal Bermuda is better than Pangola in this trait also. These facts are very important, as most of the nutritional value of a forage grass is in its leaves.

There is no doubt of the superiority in yield and probably in total nutritive value of Guinea grass to Pará, Pangola, molasses, and molasses-kudzu for grazing, due possibly to a higher percentage of leaves. Guinea is the grass to recommend if it is properly managed with adequate fertilization, if rotational grazing is used to minimize "kill-out" of bunches, and if it is mowed at least once a year. This keeps bunches down to at least 8 inches, enabling Guinea to benefit from the high percentage of leaves. At least one field a year should be left to reseed itself. Proper weed control is assumed in all cases.

Most farmers want a forage grass that is easy to handle and not so exacting of good management as is Guinea. These conditions are met by Pangola grass for the humid sections of Puerto Rico and on irrigated areas. There is no choice at present but Guinea grass under good management; for the Southern and Southwestern Regions, without water of irrigation. Otherwise weeds and competing grasses soon smother it.

SUMMARY

An experiment was established at the Lajas Substation to measure the response of Guinea, which is the prevailing grass of the Valley, Pangola, and Coastal Bermuda grasses to fertilization with nitrogen at the levels of 200, 400, 800, and 1,200 pounds of nitrogen in six equal applications per year for two consecutive years under irrigation. A split-plot design was followed with four replications, grasses being tested in the large plots and nitrogen in the subplots.

The grasses were cut every 60 days and the following classes of data were taken for comparisons: 1, Yields of green and dry matter per acre per year; 2, hay yields per acre, using an all-crop dryer and adjusting yields to 20-percent moisture for uniformity; 3, gross-energy values as affected by treatment; 4, percentage of protein and total protein per acre as affected by treatment; 5, leaf-to-stem ratio; 6, observations on palatability of the hays produced; 7, other observations.

Generally speaking, and with few exceptions, highly significant differences were found in yield per acre of green forage, dry matter, hay, and total protein for all three grasses between the high and lower nitrogen treatments. No differences were found between the two high-nitrogen treatments.

Seasonal variation was measured. There was an increase in yield for the three grasses, starting in April with a peak in September, and a reduction starting in late October with the lowest yield in January no matter how much water and fertilizer was applied. Tentative recommendations are made. Further work is being carried on, however.

RESUMEN

Se estableció un experimento en el Valle de Lajas con el propósito de medir los efectos de distintas aplicaciones de nitrógeno (200, 400, 800 y 1,200 libras por cuerda al año) en las yerbas Guinea (predominante en el Valle), Pangola y Bermuda de Costa bajo riego controlado. Este trabajo se llevó a cabo durante dos años consecutivos. Las yerbas se cortaron cada 60 días y las parcelas se abonaron, después de cada corte, con una sexta parte del abono a aplicarse durante el año. Se usó un diseño que comprendía parcelas divididas con cuatro replicaciones y en el cual las yerbas se compararon en las parcelas grandes y las cantidades de nitrógeno en las parcelas pequeñas.

Se estudiaron los siguientes detalles:

1. Rendimiento de materia verde y materia seca por cuerda por año.
2. Producción de heno por cuerda, ajustando la humedad a un 20 por ciento para las comparaciones. Se usó una secadora pequeña de cosechas.
3. Energía bruta de cada una de las yerbas y cómo fue afectada por los distintos tratamientos.
4. Porcentaje de proteína total por cuerda, según los tratamientos.
5. Medidas de los efectos de las variaciones estacionales sobre la producción.
6. Efecto de los tratamientos en cuanto a la proporción de tallos a hojas.
7. Observaciones en cuanto a la aceptación por cabras y vacas de los henos producidos de las distintas yerbas.

Se incluye además una discusión sobre la capacidad de estas yerbas, según cada tratamiento, para sostener cabezas de ganado.

También se discuten otras observaciones de importancia sobre estas yerbas.

LITERATURE CITED

1. Bonnet, J. A., and Brenes, E. J., Detailed Salinity Survey of Lajas Valley, Agr. Exp. Sta. Univ. P.R., Bul. 141, July 1958.
2. Little, S., Vicente, J., and Abruña, J., The yield and protein content of irrigated Napier grass, Guinea grass, and Pangola grass as affected by nitrogen fertilization, *Agron. J.*, **51**(2) 111–3, 1959.
3. Lugo-López, M., Pérez Escolar, R., Acevedo, G., and Juárez, J., Jr., Nature and Properties of Major Soils of Lajas Valley, Agr. Exp. Sta. Univ. P.R., Bul. 149, June 1959.

4. Rivera Brenes, L., Technical and Economic Aspects of Roughage Production in Puerto Rico, Agr. Exp. Sta. Univ. P.R., Tech. Paper 12, 1953.
5. Rivera Brenes, L., Colón Torres, E. N., Gelpí, F., and Torres Más, J., Influence of nitrogen fertilization on guinea grass yield and carrying capacity in Lajas Valley, *J. Agr. Univ. P.R.*, **42**(4) 239–47, 1958.
6. Rodríguez, J. P., Effect of nitrogen applications on the yields and composition of forage crops, *J. Agr. Univ. P.R.*, **33**(3) 98–117, 1949.
7. Vicente, J. and Figarella, J., Growth characteristics of guinea grass on the semi-arid south coast of Puerto Rico and the effect of nitrogen fertilization on forage yields and protein content, *J. Agr. Univ. P.R.*, **42**(3) 151–60, 1958.
8. Vicente, J., Silva, S., and Figarella, J., The effect of nitrogen fertilization and frequency of cutting on the yield and composition of three tropical grasses, *Agron. J.*, **51**(4) 202–6, 1959.
9. Vicente, J., Rivera Brenes, L., Caro Costas, R., Rodríguez, J. P., Boneta, E., and Gracia, W., The Management and Utilization of the Forage Crops of Puerto Rico, Agr. Exp. Sta. Univ. P.R., Bul. 116, Dec. 1953.

Palatability Tests on Giant Pangola grass (*Digitaria valida* Stent) and Signal grass (*Brachiaria brizantha*) as compared with Napier (Merker) grass (*Pennisetum purpureum*)

L. Rivera Brenes, J. A. Arroyo, H. Cestero, and A. Sierra[1]

INTRODUCTION

Signal grass (*Brachiaria brizantha*) and Giant Pangola grass (*Digitaria valida Stent*) were introduced into Puerto Rico by the Agricultural Experiment Station during the course of the year 1957. The first was introduced from Ceylon and the second from Cuba. Signal grass is widely used in Ceylon and Giant Pangola grass is planted in Cuba, but we do not know to what extent. No technical literature has been received from Cuba on this grass.

Napier grass is very palatable (*3*)[2] and is used for comparison purposes. Unpublished data of this Station on yield per acre (*4*) indicate that both Signal and Giant Pangola compare favorably with other forage grasses in the Island.

A palatability test was made after obtaining preliminary information on the behavior of these grasses in the field, and before further and more extensive experimentation is conducted. The results of this trial are reported here.

PROCEDURE

The experiment performed to compare the relative palatabilities of the three grasses was set up using a 3 x 3 Latin-square design with a 7-day prefeeding period and a 7-day collection period (*1*). Three animals were used per group. The grasses were fertilized at the rates of 400 pounds of N, 300 of P_2O_5, and 300 of K_2O per acre per year. They were cut starting at an age between 40 to 50 days when they were green and tender.

Early in the morning each day enough grass was cut from each plot to feed the corresponding group. The grasses were chopped in a silage-chopper in the barn where the animals were. Samples were taken for the determination of moisture content and calculation of dry-matter intake. Digestibility

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[2] Italic numbers in parentheses refer to Literature Cited. p. 150.

determinations were also made; information on the results of these determinations is reported separately.

Open, dry cows and 2-year-old heifers were used for the experiment. They were weighed every morning during the collection periods. Total consumption was measured every day. Forages were offered to the animals in three or four servings during the day. At night they were put out in an exercise lot where they had access only to water. Both fresh-material and dry-matter consumption were calculated per 100 pounds of live weight for uniformity. Chemical analyses were made according to the A.O.A.C. Official Methods. The data were statistically analyzed.

TABLE 1.—*Crude-protein and dry-matter contents (percent) of the 3 grasses, average of all trials*

Grass	Crude protein	Dry matter
Napier	6.63	16.58
Giant Pangola	5.93	21.32
Signal	5.39	22.51

RESULTS AND DISCUSSION

Data for the average pounds of fresh forage and dry matter per 100 pounds of live weight consumed from each grass are presented in the following tabulation:

Napier grass		*Giant Pangola grass*		*Signal grass*	
Fresh forage	*Dry matter*	*Fresh forage*	*Dry matter*	*Fresh forage*	*Dry matter*
11.77	1.89	9.92	2.11	8.70	1.95

The average chemical analyses for crude protein and dry matter are given in table 1. Napier grass is higher in protein content but much lower in dry matter than Giant Pangola and Signal grasses.

As shown in the tabulation the animals consumed more fresh Napier grass, but because the dry-matter content of the other two grasses was higher, the intake of dry matter was essentially the same for the three.

Statistical analyses presented in table 2 showed no significant difference between the grasses either for fresh-material or for dry-matter intake.

The two new grasses are as palatable as Napier with the advantage over it that the animals ingest more dry matter per pound of fresh forage eaten. This is a very important factor in cattle nutrition in Puerto Rico where hay is not used and it is difficult for our cattle to ingest large amounts of dry matter from our common forages which have a very high moisture content.

Figure 1 presents the dry-matter consumption by a 900-pound cow on Napier, Giant Pangola, and Signal grasses. According to Morrison Standards (*2*) a 900-pound cow needs from 6.4 to 7.2 pounds of T.D.N. for maintenance. Assuming 50-percent T.D.N. for the dry matter consumed in the forages under test, all three grasses rated far over Morrison's high limit. Giant Pangola was somewhat higher than the other two.

TABLE 2.—*Results of the statistical analyses on palatability as pounds of green roughage and dry matter consumed per 100 lb. of live weight for the 3 grasses*

Source of variance	Green forage				Dry matter			
	D.F.	S.S.	M.S.	F.	D.F.	S.S.	M.S.	F.
Total	8	30.06			8	0.17		
Periods	2	8.77			2	.04		
Groups	2	4.51			2	.03		
Grasses	2	14.37	7.19	5.94[1]	2	.08	0.04	4.00[1]
Error	2	2.41	1.21		2	.02	.01	

[1] Not significant.

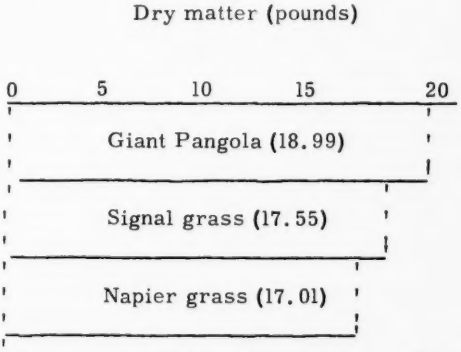

FIG. 1.—Dry-matter consumption by a 900-pound cow of Giant Pangola grass, Signal grass, and Napier grass.

SUMMARY AND CONCLUSIONS

Signal grass (*Brachiaria brizantha*) and Giant Pangola (*Digitaria valida Stent*) were introduced into Puerto Rico by the Agricultural Experiment Station in 1957, from Ceylon and Cuba, respectively. Field observations and unpublished data on yields indicate good forage possibilities for these grasses for the Island.

Both were submitted to a palatability test and compared with Napier grass, (*Pennisetum purpureum*), which is one of our most palatable forage

grasses, using a 3 x 3 Latin-square design. The two grasses are as palatable as and contain more dry matter per pound of green forage than Napier grass.

Both grasses are under grazing trials and must be submitted to more field observations before final recommendations are given to the farmers.

RESUMEN

En 1957, la Estación Experimental Agrícola de la Universidad de Puerto Rico introdujo la yerba Estación (*Brachiaria brizantha*) de Ceylán y la Pangola Gigante (*Digitaria valida* Stent) de Cuba. Las observaciones de campo y datos de rendimientos, aún sin publicar, indican que estas yerbas son buenas para forraje y por lo tanto prometedoras. Ambas se han sometido a pruebas para determinar hasta qué grado las apetece el ganado, en comparación con la yerba Napier (Merker), la cual es una de las más apetecidas. Los resultados de estas pruebas, en las cuales se usó el cuadrado latino 3 x 3, han demostrado que ambas yerbas son tan apetecidas por el ganado como la Napier (Merker) y contienen más materia seca por libra de forraje verde que ésta.

Actualmente, ambas yerbas están en prueba de pastoreo para lo cual se continuarán las observaciones. No se hará una recomendación definitiva a los agricultores sobre la conveniencia de sembrar comercialmente estas yerbas hasta haber recogido y analizado todos los experimentos que se están llevando a cabo.

LITERATURE CITED

1. Anonymous, Summary of proceedings of a conference held at Beltsville, Md., Feb. 20–21, 1956, on Procedures and Technics Used in Silage Studies, USDA, Washington, D.C., L. A. Moore, Chairman.
2. Morrison, F. B., Feeds and Feeding, The Morrison Publishing Co., Ithaca, N.Y., Feb. 22, 1956.
3. Rivera Brenes, L., Herencia, J., Arroyo, J. A., and Cabrera, J. I., Palatability trials on Merker grass (*Pennisetum purpureum*), Venezuela grass (*Paspalum fasciculatim*), and plaintain pseudostalks (*Musa paradisiaca*), *J. Agr. Univ. P.R.* **43**(4), 249–54, 1959.
4. Sotomayor, A., Personal communication of unpublished data on fieldwork with the grasses used in our work, Genetics Dept., Agr. Exp. Sta., Río Piedras, P.R., 1960.

Digestibility Studies on Napier (Merker) Grass (*Pennisetum purpureum*), Giant Pangola Grass (*Digitaria valida* Stent), and Signal Grass (*Brachiaria brizantha*)

J. A. Arroyo and L. Rivera Brenes[1]

INTRODUCTION

The data reported in this paper are the results of digestion trials performed on Napier (Merker) grass (*Pennisetum purpureum*), Giant Pangola grass (*Digitaria valida Stent*), and Signal grass (*Brachiaria brizantha*). Digestion trials and palatability tests were conducted concurrently with these forages. Palatability results were reported separately (*6*)[2].

Napier (Merker) grass was introduced into the Island by the Agricultural Experiment Station of the University of Puerto Rico in 1934, from Mississippi. It is the most important soilage grass actually grown in the Island. Besides its high yield per acre, from 70 to over 100 tons per acre per year (*8, 10*), its high palatability is well known to all farmers (*7*).

Giant Pangola grass was introduced from Cuba by this Station in 1957. After some fieldwork it looks like a promising forage grass and is being evaluated accordingly. It was found as palatable as Napier (Merker) grass (*6*).

Signal grass was also introduced into Puerto Rico by this Station from Ceylon in 1957 (*3*). It is widely used in that country. It has a number of good characteristics which make it also look promising. It is as palatable as Napier (Merker) grass and as Giant Pangola (*6*). This grass has been described as a different strain from the one found in Puerto Rico (*4*).

This paper reports the values for digestible energy, digestible protein, and total digestible nutrients for these two new grasses as compared with Napier grass (Merker). These criteria are recommended by Swift (*9*).

PROCEDURE

The experiment consisted of two trials on each of the three grasses with a 7-day prefeeding period and a 5-day collection period. Three groups of three cows were used for each trial.

The grasses were about 50 days old at the first trial and about 80 days at the second. That is, for the first digestion trial the grasses were green

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[2] Italic numbers in parentheses refer to Literature Cited. p. 155–6.

and tender and less mature than for the second. Each trial is reported separately and then the two are averaged.

The grasses were fertilized at the rate of 400 pounds of N, 300 of P_2O_5, and 300 of K_2O per acre per year, and one-sixth of that amount was applied to the plots as if they were going to be cut every 2 months.

The needed daily forage from each grass was cut in the morning, chopped in a silage-chopper, and fed to the cows in three or four servings during the day. All forage offered, as well as that refused, was carefully collected and weighed for each 24-hour-period for 5 consecutive days. All animals were weighed every day in the morning, around 7:00 a.m. and were kept continuously in the stanchions during the collection period.

A 25-gm. sample of fecal material was collected twice daily, in the morning and in the afternoon. The samples were accumulated in the same jar to a total of 250 gm. throughout the collection period. A 500-gm. sample of each roughage material was collected once a day after the grass was chopped and thoroughly mixed with a shovel. Fecal and roughage samples were air-dried at 70°C. for 5 days for dry-matter determinations.

The dried samples were ground in a Wiley mill and placed in glass bottles. Crude-protein determinations were made according to A.O.A.C. Official Methods (*1*). Calorimetric determinations were made according to the Parr oxygen-bomb combustion method (*2*). A total of 42 roughage and 18 fecal samples were analyzed.

Conversion of digestible energy to T.D.N. was made according to Swift (*9*).

RESULTS AND DISCUSSION

The results of each digestion trial are reported separately for comparison purposes, and then the data are averaged.

Table 1 presents the green-roughage and dry-matter consumed, as well as the feces and dry matter excreted for the first and second digestion trials. Generally speaking, the consumption of dry matter increased in the second digestion trial. This, of course, was expected, because of the condition of the grasses when more mature, principally Napier.

The consumption of green Giant Pangola is to be noted. It increased in the second trial, as did the dry matter. The grasses were about 50 days old for the first digestion trial and about 80 for the second. This implies a reduction in palatability due to coarseness of the material. It was true for Napier and Signal grasses but not for Giant Pangola.

Table 2 presents the dry matter, crude protein, and gross energy for the three grasses and also for the fecal samples of the same, first and second digestion trials. As can be seen Giant Pangola and Signal grasses contain more dry matter per pound of green grass than Napier. Dry-matter content

for these two grasses did not vary markedly from one age, 50 days, to the other, 80 days. The dry-matter content of Napier increased as expected. Crude protein naturally decreased with age for the three grasses.

TABLE 1.—*Green roughage and dry matter (pounds) consumed, and feces and dry matter eliminated per day during the 2 digestion trials on 3 grasses at different ages, using 3 cows*

Grass	Average roughage consumption per day	Average dry-matter consumption per day	Average fecal elimination per day	Average dry-matter elimination per day
First digestion trial on 50-day-old grasses				
Napier (Merker)	109.87	13.66	42.87	6.82
Giant Pangola	74.00	15.67	42.17	7.28
Signal	70.27	14.76	43.60	7.78
Second digestion trial on 80-day-old grasses				
Napier (Merker)	78.7	15.42	48.67	7.81
Giant Pangola	77.07	16.62	48.30	7.30
Signal	61.30	14.07	38.60	6.77

TABLE 2.—*Dry-matter, crude-protein, and gross-energy values for Napier (Merker), Giant Pangola, and Signal grasses of 2 different ages, and 3 fecal samples (dry basis), for the first and second digestion trials, using 7 and 3 cows, respectively*

Grass	Forages				Feces			
	Dry matter	Crude protein	Gross energy		Dry matter	Crude protein	Gross energy	
First digestion trial on 50-day-old grasses								
	Percent	*Percent*	*Cal./gm.*	*Therms*	*Percent*	*Percent*	*Cal./gm.*	*Therms*
Napier (Merker)	12.43	8.30	4.71	2.14	15.96	8.04	4.87	2.21
Giant Pangola	21.17	6.29	5.00	2.27	17.29	7.47	5.16	2.34
Signal	21.00	6.07	5.43	2.46	17.87	7.33	4.88	2.16
Second digestion trial on 80-day-old grasses								
Napier (Merker)	19.59	5.23	5.21	2.37	16.05	6.15	5.46	2.48
Giant Pangola	21.56	5.43	5.48	2.49	14.97	6.96	5.21	2.36
Signal	22.95	4.66	5.39	2.47	17.61	5.87	5.39	2.44

Table 3 presents the digestible-energy, digestible-protein, and total digestible-nutrient values for the two trials. Both Giant Pangola and Signal grass had more digestible energy and total digestible nutrients than Napier

in the two digestion trials. Napier, though, was higher in digestible protein in the first trial, when younger. Apparently age did not affect the digestibility of Giant Pangola, the results of these trials show an increase. These

TABLE 3.—*Digestible-energy, digestible-protein, and T.D.N. values for Napier (Merker), Giant Pangola, and Signal grasses of different ages for the first and second digestion trials, using 3 cows*

Grass	Digestible energy			T. D. N.		Digestible protein	Digestible coefficient
First digestion trial on 50-day-old grasses							
	Cal.	*Therms*	*Percent*	*Pounds*	*Percent*	*Percent*	*Percent*
Napier (Merker)	14,130.84	14.13	48.38	7.11	52.05	4.28	51.63
Giant Pangola	18,445.34	18.44	52.00	9.28	59.22	2.82	44.48
Signal	19,149.90	19.15	52.63	9.64	65.31	2.21	36.38
Second digestion trial on 80-day-old grasses							
Napier (Merker)	17,113.80	17.11	46.92	8.61	55.84	2.13	40.82
Giant Pangola	24,082.25	24.08	58.24	12.12	72.92	2.43	44.78
Signal	17,863.53	17.86	51.88	8.99	63.89	1.84	39.48

TABLE 4.—*Digestible-energy, digestible-protein, and T.D.N. values for Napier (Merker), Giant Pangola, and Signal grasses, of different ages showing averages of 2 trials using 6 cows*

Grass	Digestible energy			T.D.N.		Digestible protein	Digestion coefficient
	Cals.	*Therms*	*Percent*	*Pounds*	*Percent*	*Percent*	*Percent*
Napier (Merker)	15,622.32	15.62	47.65	7.86	5.395	3.21	46.23
Giant Pangola	21,263.79	21.26	55.12	10.70	66.07	2.62	44.63
Signal	18,506.72	18.51	52.26	9.32	64.60	2.03	37.93

findings are under further investigation. Palatability was not affected by age either, as shown in table 1.

Average results of the two digestion trials are given in table 4. The dry-matter content of the two new grasses, Giant Pangola and Signal, is very important from the nutritional point of view under our conditions. It is very hard to make any dairy cow eat enough dry matter for maintenance and derive a reasonable part of its production from young Napier (Merker), Guinea, or Pará grass, because their moisture contents are over 80 percent.

With these two new grasses the situation can be improved considerably; see table 1.

More work on evaluation of these two grasses is being carried out.

SUMMARY

Digestible energy and digestible protein were determined for Giant Pangola (*Digitaria valida Stent*), Signal (*Brachiaria brizantha*), and Napier (Merker) (*Pennisetum prupureum*) grasses. Total digestible nutrients were also calculated. Digestible protein for Napier (Merker), Giant Pangola, and Signal grasses were 3.21, 2.62, and 2.03 percent. Total digestible nutrients in the same order were, 53.95, 66.07, and 64.60 percent.

Two digestion trials were made, one when the grasses were about 50 and the other when they were about 80 days old. The average digestion coefficient for energy for Napier (Merker) was 47.65 percent, for Giant Pangola 55.12, and for Signal grass 52.26.

Both Giant Pangola and Signal grasses are much higher in dry-matter content than Napier (Merker) at 50 days of age, a very important characteristic nutritionally speaking.

RESUMEN

A las yerbas Pangola Gigante, Napier (Merker) y Estación se les determinó la energía y proteína digeribles. También se les calculó su cantidad total de nutrientes digeribles.

Se hicieron dos pruebas de digestibilidad; una cuando tenían alrededor de 50 días de sembradas y otra a los 80 días, más o menos.

El promedio de los coeficientes de digestibilidad para energía fue como sigue: Napier (Merker) 47.65 por ciento; Pangola Gigante 55.12 por ciento; y Estación 52.26. El porcentaje de proteína digerible fue, para la Napier (Merker) 3.21, para la Pangola Gigante 2.62 y para la Estación 2.03. El porcentaje total de nutrientes digeribles fue 53.95, 66.07 y 64.60 para las tres yerbas en el mismo orden respectivo.

Tanto la Pangola Gigante, como la Estación contienen mayor cantidad de materia seca que la Napier (Merker), a los 50 días de sembradas. Este es un carácter muy importante de estas yerbas desde el punto de vista nutricional.

LITERATURE CITED

1. Association of Official Agricultural Chemists, Methods of Analysis, 8th ed., Washington, D.C., 1955.
2. Oxygen Bomb Calorimetry and Oxygen Bomb Combustion Methods, Manual 120, Parr Instrument Co., Moline, Ill., 1948.
3. Rivera Brenes, L., Informe Semestral enero 1 a julio 31 de 1959, Depto. de Zootec-

nia, Estación Experimental Agrícola, U.P.R., Río Piedras, P.R., 25 de agosto de 1959.

4. —, Informe Semestral agosto 1 de 1959 a enero 31 de 1960, Depto. de Zootecnia, Estación Experimental Agrícola, U.P.R., Río Piedras, P.R., 12 de julio de 1960.
5. —, Informe Semestral febrero 1 a junio 30 de 1960, Depto. de Zootecnia, Estación Experimental Agrícola, U.P.R., Río Piedras, P.R., 12 de julio de 1960.
6. Rivera Brenes, L., Arroyo, J. A., Cestero, H., and Sierra, A., Palatability tests on Giant Pangola grass (*Digitaria valida* Stent) and Signal grass (*Brachiaria brizantha*) as compared with Napier (Merker) grass (*Pennisetum purpureum*), *J. Agr. Univ. P.R.* **45**(3) 147–50, 1961.
7. Rivera Brenes, L., Herencia, J., Arroyo, J. A., and Cabrera, J. I., Palatability trials on Merker grass (*Pennisetum purpureum*), Venezuela grass (*Paspalum fasciculatum*), and plantain pseudostalks, (*Musa paradisiaca*), *J. Agr. Univ. P.R.*, **43**(4) 249–54, 1959.
8. Rivera Brenes, L., Technical and Economic Aspects of Roughage Production in Puerto Rico, Agr. Exp. Sta. Univ. P.R., Río Piedras, P.R., Tech. Bul. 12, Sept. 1953.
9. Swift, R. W., The Nutritive Evaluation of Forages, Pa. State Univ., University Park, Pa., Bul. 615, Jan. 1957.
10. Vicente-Chandler, José, Silva, Servando, and Figarella, Jacinti, Effects of nitrogen fertilization and frequency of cutting on the yield and composition of Napier grass in Puerto Rico; Effects of nitrogen fertilization and frequency of cutting on the yield and composition of Guinea grass in Puerto Rico; and Effects of nitrogen fertilization and frequency of cutting on the yield and composition of Para grass in Puerto Rico, *J. Agr. Univ. P.R.* **43**(4) 215–48, 1959.

Degree of Reclamation of a Saline-Sodic Soil in Lajas Valley, Puerto Rico[1]

G. Acevedo Ramos, J. A. Bonnet, and J. Ortiz Vélez[2]

INTRODUCTION

In Puerto Rico there is urgent need to increase the area of productive cultivated land in order to produce more food for the 2⅓ million inhabitants and so help to improve the general welfare of the Island. The Lajas Valley in southwestern Puerto Rico constitutes one of the last frontiers for extending cultivated land in the Island. A drainage-irrigation reclamation project had advanced to the point that there are already large tracts under intensive cultivation in the Valley. However, the arid lowlands of Lajas Valley are to some extent affected by sporadic extensive patches with salinity problems.

In 1945, the Soils Department of the Agricultural Experiment Station of the University of Puerto Rico initiated extensive studies of the soil problems of Lajas Valley. These studies included morphological, physical, chemical, and mineralogical characterization; irrigation-water quality; and measurements of infiltration rates and leaching tests under field conditions (*1*, *2*).[3] A more detailed salinity survey of the Valley was conducted from July 1954 to March 1955, comprising a total area of 24,544 acres (*3*, *4*). The proportions of normal, saline-sodic, nonsaline-sodic, and saline soils of the area studied, as reported by Bonnet and Brenes, are shown in table 1 (*5*). Since the survey of the salinity status of the soils indicated that the saline-sodic soils presented the major problems, and that such soil increases in area with depth, it was considered advisable to select a saline-sodic soil for experimental work on reclamation procedures.

This paper reports the preliminary results obtained in the attempt to reclaim with chemicals and organic amendments such a saline-sodic soil.

[1] Joint contribution from the Department of Soils and the Lajas and Gurabo Substations.

[2] Research Assistant in Soils, Soil Chemist and Head Department of Soils, and Assistant Drainage Scientist, respectively, Agricultural Experiment Station, University of Puerto Rico, Río Piedras, P.R. Appreciation is expressed to E. J. Brenes, Assistant Soil Scientist, for his help in planning and during the initial stages of the work, and to Dr. M. A. Lugo-López, Assistant Director in Charge of the Gurabo Substation, for helpful suggestions in the preparation of the manuscript. The authors also wish to express their appreciation to R. Pérez Escolar, Assistant Soil Scientist, F. Díaz, Research Assistant in Irrigation Engineering, and L. S. Willardson, former Irrigation Engineer of Lajas Substation, for their help in soil sampling, irrigation of the experiment, and providing adequate drainage for it, respectively.

[3] Italic numbers in parentheses refer to Literature Cited, p. 170–1.

MATERIALS AND METHODS

The reclamation experiment was started on a saline-sodic soil in the northeastern part of Lajas Valley. The soil, classified as Fe clay, is a heavy dark-gray, plastic clay grumusol with numerous lime concretions. Gypsum crystals are found at lower depths. Montmorillonite is the dominant clay mineral. Hydraulic conductivity is slow, especially in the lower subsoil and, in general, the physical properties are rather undesirable (*7*, *9*).

The area studied was divided into 24 plots 15 by 20 feet in size each. Earth borders were erected to form individual basins. Because subsurface drainage is essential for the reclamation of saline-sodic soils with low permeability, tile drains were installed at a 6-foot depth and a 60-foot spacing. The tiles were packed in gravel and the effluent discharged into an open drain connected to the main drainage canal of the Lajas Valley. At the

TABLE 1.—*Percentages of normal, saline-sodic, nonsaline-sodic, and saline soils, according to depth of sampling, in 24,544 acres surveyed and sampled in the Lajas Valley*[1]

Depth (inches)	Normal	Saline-sodic	Nonsaline-sodic	Saline
0–8	86	8	1	5
8–24	64	20	8	8
24–48	34	48	11	8
48–72	23	58	11	8

[1] Reported by Bonnet and Brenes (*5*).

beginning of the experiment a heavy rainfall caused considerable damage to the experimental site; the earth borders were washed out and the ditches destroyed. The earth borders were than replaced by aluminum sheets painted black to protect them from salt corrosion (fig. 1).

The treatments, replicated four times in a partly balanced incomplete-block design, were as follows:

Treatment No.	*Amendment*
1	Check
2	do.
3	Bagasse (10 ton/acre)
4	Bagasse (10 ton/acre) + $CaCl_2$ (equivalent to 4 ton/acre of sulfur)
5	Sulfur (4 ton/acre)
6	Bagasse (10 ton/acre + sulfur (4 ton/acre)

The bagasse and the sulfur were broadcast on the surface soil and then incorporated by means of a rotavator. All plots were flooded with fresh

water at various time intervals using a portable gasoline-driven centrifugal pump. All treatments, except one check group left bare, were to be planted with a suitable crop at a convenient time after reclamation.

Soil samples were taken periodically at the following depths: 0–8, 8–16, 16–24, 24–36, and 36–48 inches, after applying, respectively, 34, 50, and

FIG. 1.—View of experimental plots used for the experiment on reclamation of a saline-sodic soil in Lajas Valley, P.R.

TABLE 2.—*Percentages of the all-treatments mean salt content of the saline-sodic soil removed in relation to depth after increased applications of water*

Depth (inches)	Salt removed after the application of—		
	34 inches of water	50 inches of water	94 inches of water
0–8	65.6	73.9	76.5
8–16	60.8	70.9	71.7
16–24	39.9	59.0	54.5
24–36	38.1	53.5	41.2
36–48	28.9	43.1	22.2

94 inches of water of irrigation and rainfall. The samples were air-dried and ground in a corn mill.

A saturated soil paste was then prepared using 100 gm. of air-dry soil to obtain a water-saturation extract following the procedure outlined in Agricultural Handbook 60 (*8*). The electrical conductivity (EC) of the soil extract expressed in millimhos per centimeter at 25°C and the exchangeable sodium percentage (ESP) of the soil were used as indices of the reclama-

tion effectiveness. The EC value multiplied by 10 expressed the total soluble-salt content in terms of milliequivalents per liter. The ESP value was obtained from the monogram on page 103 of the above-mentioned Handbook.

TABLE 3.—*Mean exchangeable sodium percentages for all treatments in the saline-sodic soil removed after increased application of water*

Depth (inches)	Exchangeable sodium percentage removed after the application of—		
	34 inches of water	50 inches of water	94 inches of water
0–8	39	46	44
8–16	15	27	19
16–24	12	22	18
24–36	9	18	8
36–48	1	10	3

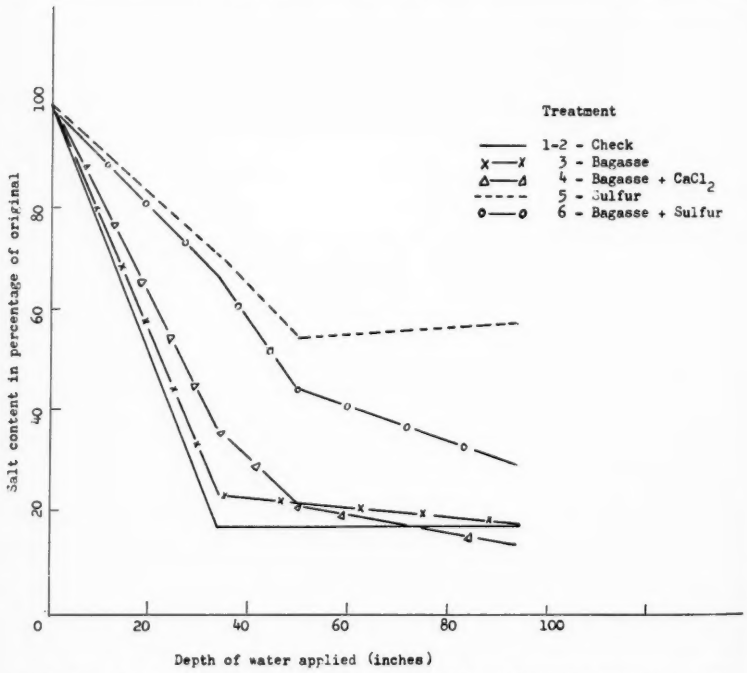

FIG. 2.—Salts removed at a soil depth of 0–8 inches with increasing water applications from different treatments.

RESULTS AND DISCUSSION

Tables 2 and 3 present data on the removal of mean soluble salts and of mean ESP corresponding to the treatments given the saline-sodic soil under reclamation in Lajas Valley. The soluble-salt content of the soil in all treatments was reduced by the water applied (figs. 2 to 6). However in the

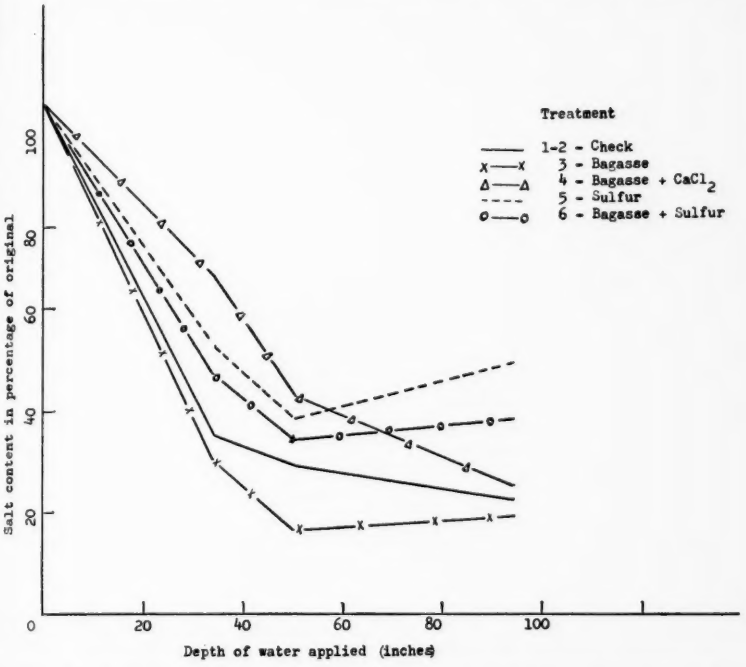

FIG. 3.—Salts removed at a soil depth of 8–16 inches with increasing water applications from different treatments.

check, 1–2, and under treatments 3 and 4, the soluble salts in the soil were reduced more rapidly in the 0-8-inch layer than under treatments 5 and 6 (figs. 2 to 6). The leaching of salts was caused by the water since no chemical amendments were added to the check plots nor to those that received bagasse. In treatment 4, which received bagasse and calcium chloride, the salts were lowered rapidly because of the combined effect of calcium chloride, by its flocculating action, and of bagasse by its favorable influence on the soil physical properties which induced a more rapid infiltration and

movement of water through the clay profile. In the sulfur treatment the sulfur apparently mobilized some of the soil insoluble calcium carbonate (*6*) into soluble form and, to some extent, maintained the soil extract EC at higher values. In the plots that received bagasse and sulfur the considerable decrease in salt content could probably be explained by the favorable effect of the bagasse on the physical condition of the soil.

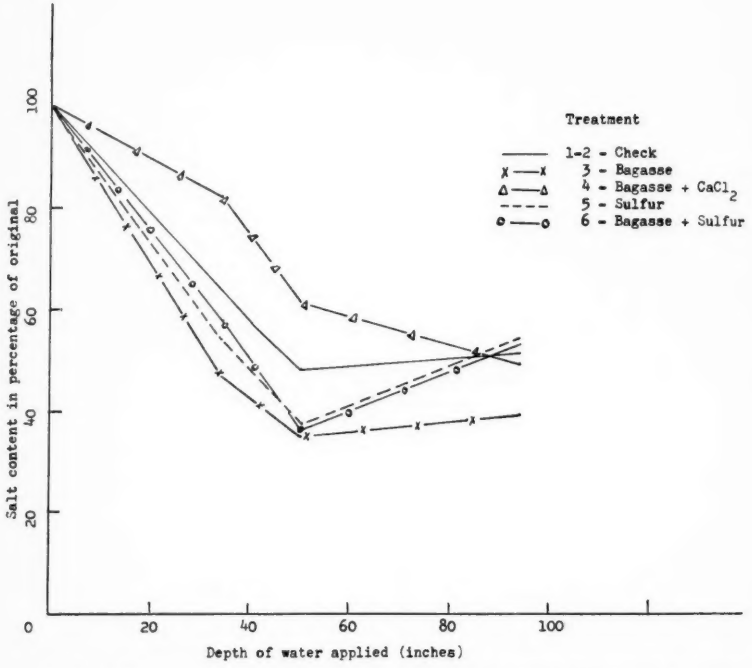

FIG. 4.—Salts removed at a soil depth of 16–24 inches with increasing water applications from different treatments.

In all cases the reduction of the salt content was more effective in the upper layers of the soil, as shown in figures 2 to 6 and in table 2. At least the water added was more effective in leaching the surface-soil layer since the salt removed from the top may have accumulated at the lower soil levels. The low permeability of the subsoil also prevented the lower layers from receiving an effective amount of water for the removal of soluble salts. It is of importance to know the effect of continued additions of water on the salt movement at the soil profile's lower depths.

Since the water applied considerably reduced the soluble salts in the saline-sodic soil, especially at the beginning of the experiment and from the upper layers of the soil, the water itself can be considered as an index for properly timing the application of amendments. These should be applied only after a given quantity of water has moved through the soil profile as long as the hydraulic conductivity rate permits it. Field observations

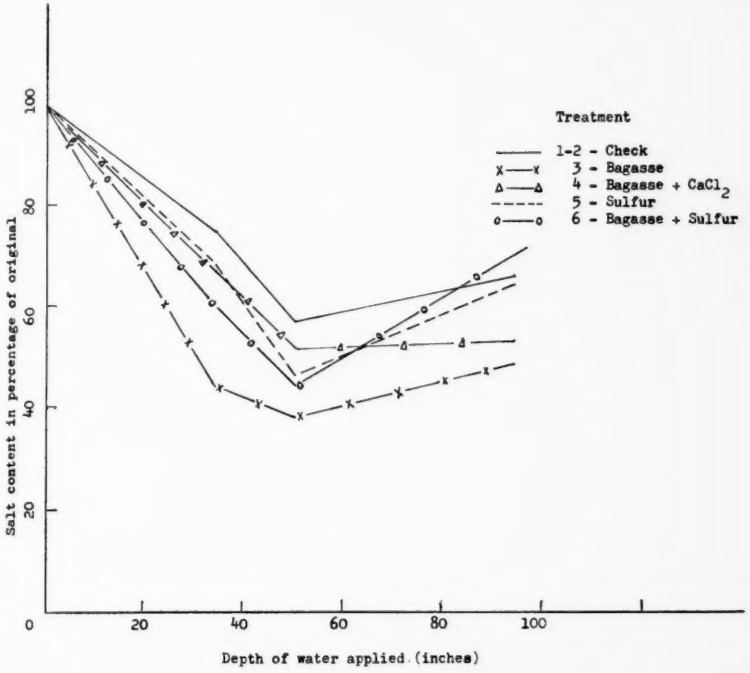

FIG. 5.—Salts removed at a soil depth of 24–36 inches with increasing water applications from different treatments.

and physical analyses demonstrated that the movement of water through this soil was slow, mainly because of its high clay content, its high exchangeable sodium, and the presence of high-swelling clay minerals, predominantly montmorillonite.

It must be clearly understood that the reclamation of a saline-sodic soil is not complete unless the exchangeable sodium of the soil colloids is reduced to a level not detrimental to plant growth and development. The harmful effect of the sodium ion on plant growth and its adverse effect on

the physical condition of the soil, dispersing and puddling it and reducing soil aereation, have been long recognized (*8*). Data on the removal of exchangeable sodium in the soil are presented graphically in figures 7 to 11. A tendency to lower exchangeable sodium with leaching is evident, especially on those plots receiving bagasse-calcium chloride, sulfur, and bagasse-

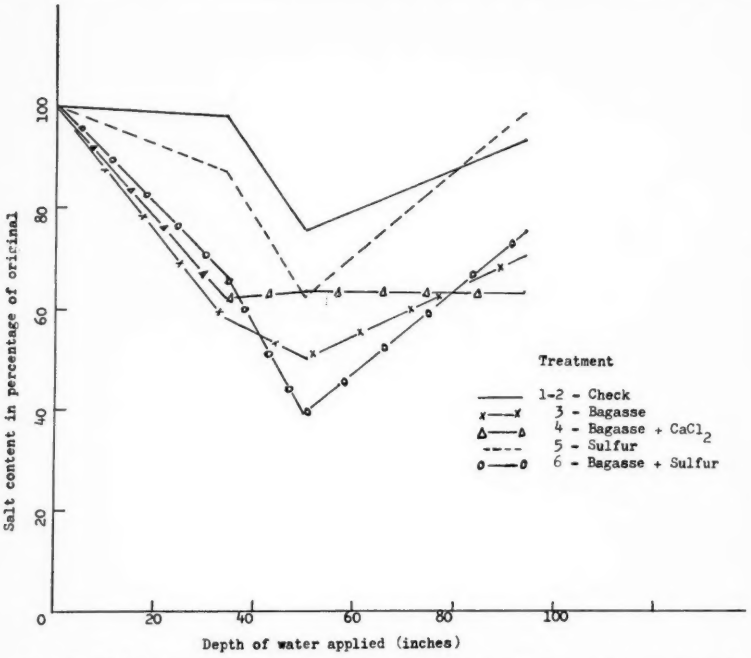

FIG. 6.—Salts removed at a soil depth of 36–48 inches with increasing water applications from different treatments.

sulfur. This was more pronounced at the uppermost layers as shown in figures 7, 8, and 9.

In contrast to the data previously discussed on the removal of soluble salts, neither water alone (check plots) nor the bagasse effectively lowered the exchangeable sodium to the desired levels. A chemical amendment such as sulfur, gypsum, or calcium chloride, is further needed for the complete reclamation of a saline-sodic soil. In figure 11 an accumulation of exchangeable sodium after the application of 34 inches of water is shown, indicating the lixiviation of sodium from the upper soil layers. The ESP

decreased with depth, as is generally shown in figures 7 to 11 and in table 3. The mean values obtained for the EC and the ESP of the soil before and after leaching with water in all treatments are presented in table 4.

Sulfur must undergo oxidation mainly by specific soil bacteria to aid in the reclamation of a saline-sodic soil. After oxidation to sulfuric acid it is

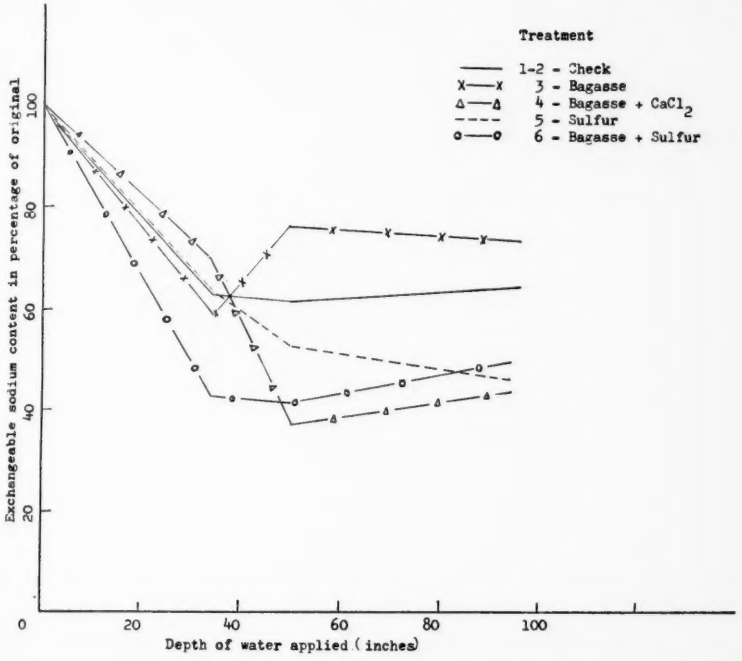

FIG. 7.—Exchangeable sodium percentage removed at a soil depth of 0–8 inches with increasing water applications under different treatments.

effective in the removal of exchangeable sodium. The bagasse provides favorable aeration conditions for the oxidation of sulfur. The sulfur treatment markedly reduced the exchangeable sodium in the surface layer, but the bagasse-sulfur treatment worked as well at the surface and lowered the ESP deeper in the soil profile as shown in figures 8 and 9.

In general, it can be concluded that, for the reclamation of a saline-sodic soil, there is need to remove both soluble salts and exchangeable sodium from it. Good soil drainage must be maintained. The experimental data so

far demonstrate that there is a tendency to lower soluble salts and exchangeable sodium in the soil after the application of 94 inches of water. This tendency is more pronounced at the surface. Additional data under process of collection at present should provide a more accurate evaluation

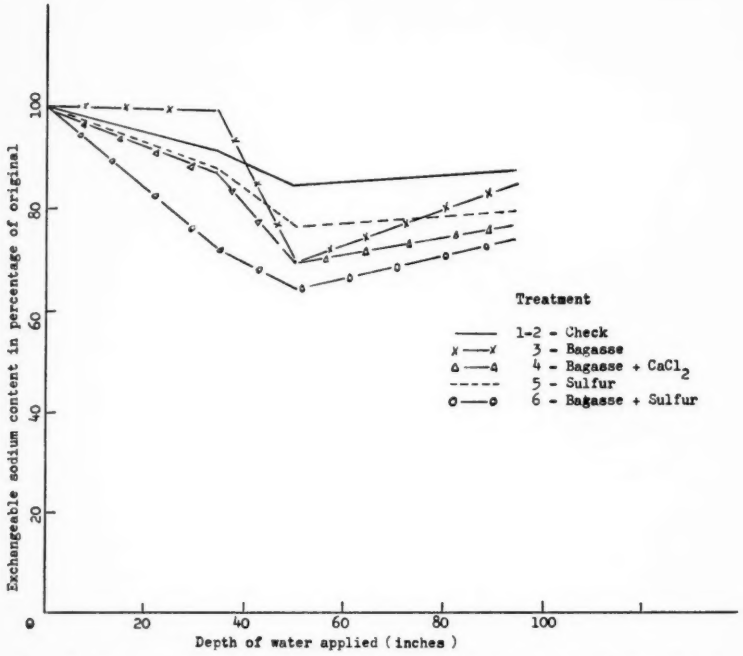

FIG. 8.—Exchangeable sodium percentage removed at a soil depth of 8–16 inches with increasing water applications under different treatments.

of the factors involved in the reclamation of saline-sodic soils under conditions similar to those that prevail in the Lajas Valley experimental set-up.

SUMMARY

In Lajas Valley, in southwestern Puerto Rico, there is a rather large portion of saline-sodic soils. These require reclamation if normal plant growth is to be sustained by them. A field experiment was initiated including six treatments: Two identical checks, and treatments with bagasse, bagasse-calcium chloride, sulfur, and bagasse-sulfur. The experimental plots were flooded periodically with fresh water. Soil samples were collected

at different depths and analyzed to study the removal of soluble salts and exchangeable sodium. Data reported include values for electrical conductivity (EC) of soil extracts and exchangeable sodium percentage (ESP) in the soil.

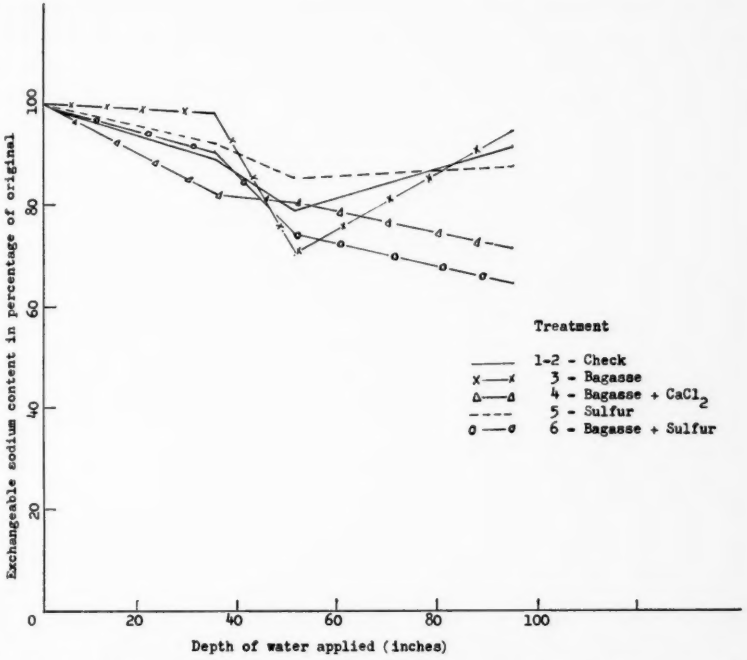

FIG. 9.—Exchangeable sodium percentage removed at a soil depth of 16–24 inches with increasing water applications under different treatments.

Results so far obtained in the reclamation experiment may be summarized as follows:

1, Application of 94 inches of water up to the maximum used to date tends to lower the soluble salts and the soil exchangeable sodium, regardless of treatment differentials.

2, The removal of the soluble salts and the reduction in exchangeable sodium were less effective in the lower layers of the soil.

3, Sulfur and calcium chloride tend to be more effective in lowering the exchangeable sodium percentage in the colloids of the surface layer of the soil.

4, There is need of a chemical amendment in addition to water and drainage if the exchangeable sodium percentage in the soil is to be lowered effectively.

RESUMEN

En el Valle de Lajas, en el suroeste de Puerto Rico, hay un gran número de suelos salino-sódicos que requieren ser restaurados para que puedan producir cosechas adecuadas. Para obtener la información básica necesaria se ha instalado un experimento de campo en uno de estos suelos. El experimento incluye seis tipos de tratamientos de las parcelas experimentales, a saber: Aplicación de bagazo, de bagazo y cloruro de calcio, de azufre, de bagazo y azufre y parcelas testigos que solo recibieron lavados con agua al igual que todas las demás parcelas. Se aplicó agua de riego de buena calidad periódicamente. Se tomaron muestras de suelo y se analizaron para estudiar el movimiento de las sales solubles y del sodio intercambiable a distintas profundidades.

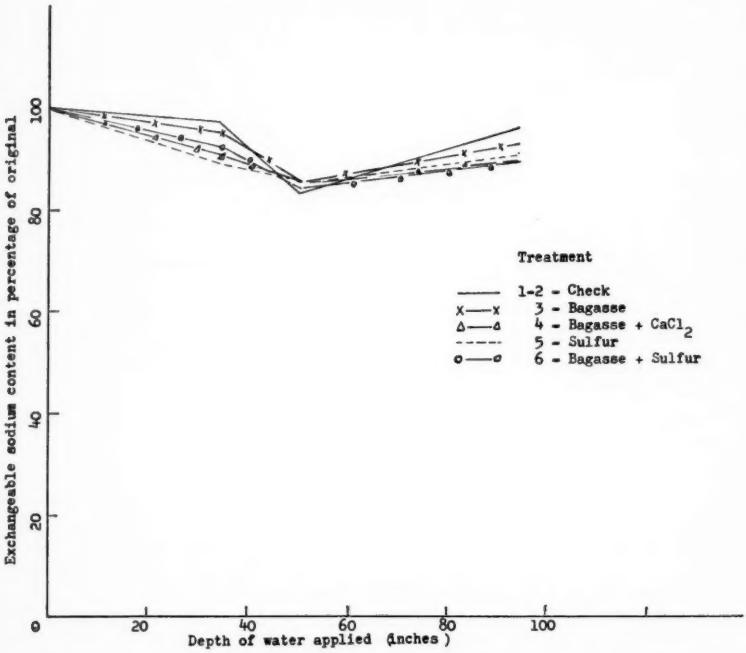

FIG. 10.—Exchangeable sodium percentage removed at a soil depth of 24-36 inches with increasing water applications under different treatments.

Los datos aquí informados incluyen valores de conductividad eléctrica de los extractos de suelo y porcentaje de sodio intercambiable en el suelo. Los resultados obtenidos hasta ahora en la restauración de un suelo salino-sódico del Valle de Lajas bajo estudio pueden resumirse en la siguiente forma:

1. La aplicación de 94 pulgadas de agua de riego claramente tiende a

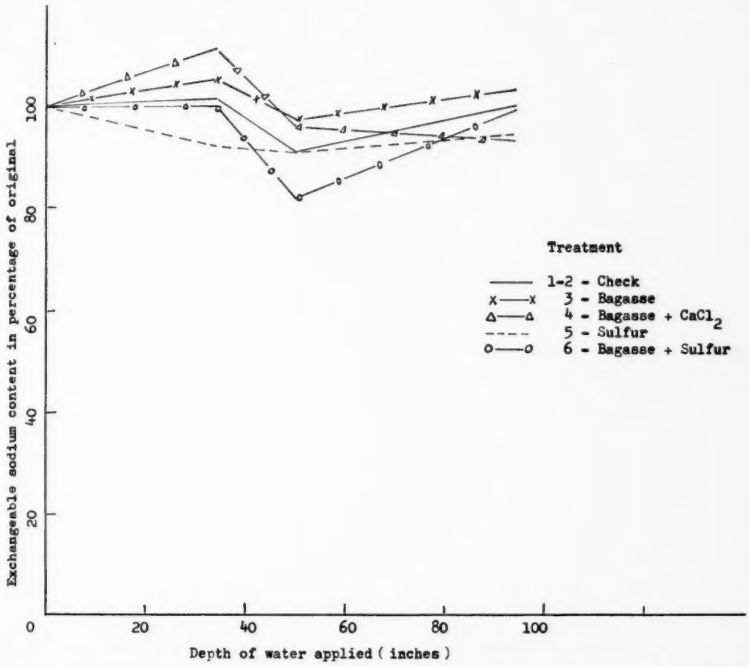

FIG. 11.—Exchangeable sodium percentage removed at a soil depth of 36–48 inches with increasing water applications under different treatments.

bajar las sales y el sodio intercambiable, sin importar las diferencias en tratamientos.

2. La remoción de sales solubles y de sodio intercambiable en el suelo es más eficaz en las capas superficiales.

3. Los tratamientos con azufre y cloruro de calcio parecen ser los más eficaces para bajar el porcentaje de sodio intercambiable en las capas superiores del suelo.

4. Se notó la necesidad de una enmienda química, además de agua y desagüe, para bajar la proporción de sodio intercambiable en el suelo.

TABLE 4.—*Mean electrical conductivity (EC) and exchangeable sodium percentage (ESP) for all treatments in the saline-sodic soil in relation to depth after increased application of water*

Treatment No.	Depth	Electrical conductivity and exchangeable sodium percentage of the original soil and after the application of—							
		0 (original soil)		34 inches of water		50 inches of water		94 inches of water	
		EC[1]	ESP[2]	EC	ESP	EC	ESP	EC	ESP
	Inches	*Mmhos/cm.*	*Percent*	*Mmhos/cm.*	*Percent*	*Mmhos/cm.*	*Percent*	*Mmhos/cm.*	*Percent*
1–2	0–8	16.5	38	2.7	25	2.0	22	2.5	24
	8–16	23.9	42	7.5	37	6.6	35	4.9	35
	16–24	31.3	40	21.6	35	14.3	33	15.0	36
	24–36	31.8	41	22.6	38	17.1	33	20.0	39
	36–48	26.0	42	23.8	42	18.0	38	22.7	42
3	0–8	15.8	33	2.3	22	2.3	24	2.1	23
	8–16	27.3	38	5.9	36	4.6	25	3.8	30
	16–24	31.3	38	13.4	37	10.1	27	11.1	36
	24–36	38.0	42	15.7	40	14.0	36	18.0	39
	36–48	32.3	42	17.0	44	14.4	39	21.0	43
4	0–8	14.3	37	4.6	25	2.8	14	1.9	16
	8–16	20.3	37	11.0	32	7.0	25	4.6	28
	16–24	26.3	37	18.6	30	13.3	29	11.0	26
	24–36	28.8	41	17.7	37	13.6	34	13.7	36
	36–48	27.8	43	16.7	47	15.9	40	15.6	39
5	0–8	14.6	36	9.7	22	7.3	19	8.1	17
	8–16	21.0	38	10.1	32	7.3	28	9.6	29
	16–24	26.5	39	13.2	35	9.5	32	13.4	34
	24–36	26.8	43	17.7	38	11.9	36	16.7	39
	36–48	22.8	44	19.4	40	13.7	39	22.2	41
6	0–8	12.8	34	7.9	14	5.4	14	3.8	16
	8–16	18.9	41	9.0	29	6.3	26	7.0	29
	16–24	22.5	41	13.2	36	8.1	30	11.9	26
	24–36	23.9	42	14.3	38	10.3	34	16.5	37
	36–48	26.8	42	16.6	42	10.6	35	19.2	42

[1] Values for EC below 4, inclusive, indicate normality as to salt content.

[2] Values for ESP below 15, inclusive, indicate normality as to exchangeable sodium content.

LITERATURE CITED

1. Bonnet, J. A., Tirado-Sulsona, P., and Lugo- López, M. A., Attempt to reclaim with chemicals a salty clay in Puerto Rico, *J. Agr. Univ. P.R.* **33**(2) 75–84, 1949.
2. Bonnet, J. A., and Tirado-Sulsona, P., Soil Studies in Lajas Valley, Univ. P.R. Agr. Exp. Sta. Bul. 86, 3–64, 1950.

3. Bonnet, J. A., and Brenes, E. J., Salinity problems on heavy calcareous impermeable clays of southwestern arid Puerto Rico, Sixiéme Congrés de la Science du Sol. Paris 515–19, 1956.
4. ——, Salinity status of Lajas Valley soils, *J. Agr. Univ. P.R.* **41**(1) 25–34, 1957.
5. ——, Detailed Salinity Survey of Lajas Valley, Univ. P.R. Agr. Exp. Sta. Bul. 141, 5–114, 1958.
6. Kelley, W. P., Alkali Soils, Their Formation, Properties, and Reclamation, Reinhold Pub. Corp., New York, N.Y., 160, 1951.
7. Lugo-López, M. A., Pérez-Escolar, R., Acevedo, G., and Juárez, Jr., J., Nature and Properties of Major Soils of Lajas Valley, Univ. P.R. Agr. Exp. Sta. Bul. 144, 1959.
8. Richards, L. A., Allison, L. E., Brown, J. W., Hayward, H. E., Berstein, L., Fireman, M., Pearson, G. A., Wilcox, L. V., Bower, C. A., Hatcher, J. T., and Reeve, R. C., U.S. Salinity Laboratory Staff, Agr. Handbook No. 60, USDA 160 pp., 1954.
9. Willardson, L. S., Lajas Valley Drainage Problems, Univ. P.R. Agr. Exp. Sta. Bul. 143, 5–64, 1958.

The Effect of Chemical Pretreatment on the Quality of Dehydrated Pigeonpeas

Abdul R. Rahman[1]

INTRODUCTION

Dehydration is the oldest method of food preservation, yet it is still practiced for specific foods on a wide commercial scale. Therefore, dehydrated foods are considered to be acceptable to the public. High-quality dehydrated food would effect considerable savings in shipping weight, space, and the amount of tinplate now needed for canned products. There would also be savings in cold storage as required for frozen foods. Any dehydrated food to be acceptable must, when reconstituted, possess a desirable appearance, texture, and flavor, and a satisfactory rehydration ratio.

Pigeonpeas do not mature uniformly on the vine, hence inmature, fully mature, and dried peas can all be obtained at the same time, and from the same tree. However, off-grade green pigeonpeas are obtained in each picking during the harvest season, and since they have limited use, a method of preserving them should be developed. The development of a successful method for the dehydration of green pigeonpeas might help in solving some of the problems, specially the expenses of the labor involved in hand-picking and grading the peas.

Pigeonpeas possess a relatively thick seedcoat which retards the evaporation of moisture during dehydration and water absorption during rehydration. This suggests the application of chemical or mechanical pretreatment which merely affects the skin in order to permit an easier and better evaporation of moisture during dehydration and better water absorption during rehydration.

REVIEW OF LITERATURE

No investigations on the dehydration of pigeonpeas are reported in the literature though numerous publications on the dehydration of other fruits and vegetables are available. No work on the dehydration of pigeonpeas has been done in Puerto Rico, but intensive research on the canning of this crop is being conducted by Sánchez-Nieva (*1*)[2] of the Food Technology

[1] Associate Food Technologist, Food Technology Laboratory, Agricultural Experiment Station, University of Puerto Rico, Río Piedras, P.R. The author wishes to extend his most sincere appreciation to the Food Technology Staff members who aided in the chemical analyses as well as in the organoleptic appraisals of the dehydrated pigeonpeas.

[2] Italic numbers in parentheses refer to Literature Cited, p. 180–1.

Laboratory. He stated that starch content, alcohol-insoluble solids, specific gravity, percentage of moisture, and flotation characteristics have been definitely established as adequate indices for the evaluation of pigeonpea maturity.

Litwiller (*2*) reported that prefreezing was essential to the dehydration process of Blue Lake green beans since it decreased the final moisture level of the dried beans and increased the rehydration at least 20 percent. Hand *et al.* (*3*) found that slitting the seed with a mechanical peacoat slitter prior to rehydration facilitated the drying process and improved the quality of the rehydrated product. Talburt and Legult (*4*) stated that dehydrofrozen peas were equal to frozen peas in quality. Rahman (*5*) reported that pretreatment with sodium hydroxide improved the quality of the dehydrated peas. Cruess (*6*) reported that dehydration intensifies any toughness that beans may originally possess. Dawson *et al.* (*7*) stated that the quality of the dehydrated product was improved by dipping light-colored fruits and vegetables, such as apples and cauliflower, into solutions of sodium sulfite and sodium bicarbonate before rehydration. Blair (*8*) pointed out in the Blair process that dipping the peas in a 2-percent solution of sodium carbonate is an important step in the protection of their natural green color. Gieseker (*9*) developed a method of preserving the color of canned green vegetables which consists of soaking them in a dilute solution of ammonium hydroxide before canning. Moyer (*10*) said that dehydrated vegetables, in general, should be added directly to boiling water. He concluded that vegetables not soaked at all were the most palatable, and rated those soaked longest as soggy.

MATERIALS AND PROCEDURES

PROCESSING

Pigeonpeas (*Cajan cajan* L) (called "gandules" or "gandures" locally) of the variety Kaki were picked, cleaned, and then blanched at 190°F. for 5 minutes in the pilot plant of the Food Technology Laboratory of the Agricultural Experiment Station. Some of the pigeonpeas were frozen to be used for further studies, especially at times when the fresh product is not available.

Four lots of pigeonpeas of equal weight were used in this study. The moisture content was 73.83 percent in two lots and 71.65 in the others. Two lots with different moisture contents were placed individually in 10-gallon glass jars, and a solution of 0.2-percent sodium hydroxide was added until all the pigeonpeas were completely submerged. The other two lots were kept in the cold room to avoid undesirable changes that might occur at room temperature while awaiting soaking of the first two lots. The soaking time was 4 hours. Upon the completion of the soaking treatments, the pigeonpeas were

transferred into perforated trays 30 x 20 x 2 inches in size and tapwater was added to wash out the residues of the sodium hydroxide. The pigeonpeas were drained for 10 minutes and then weighed.

DEHYDRATION

The four trays were placed in the Proctor and Schwartz cabinet dehydrator at the same time. The dry-bulb temperature was set at 200° F. using the cross-circulation airflow, and after 1 hour it was reduced to 150° F. for the rest of the dehydration period, which was 3 hours. The wet-bulb temperature was set at 100° F. all the time. The dehydrated peas were weighed and then placed in polyethylene bags.

RECONSTITUTION

Dehydrated peas were reconstituted by adding 250 ml. of water to each 100 gm. of dehydrated peas and heating. After boiling they were allowed to simmer for different lengths of time ranging from 10 to 90 minutes. The pigeonpeas were drained for 10 minutes and weighed. The percentage of rehydration was computed by using the following equation:

$$\frac{A \times C\ 100}{B \times D} = \text{percent rehydration.}$$

Where A = moisture-free weight of 100 gm. of fresh pigeonpeas; B = moisture-free weight of dehydrated pigeonpeas; C = increase in weight of dehydrated peas due to rehydration; D = percentage moisture in the fresh peas.

Five hundred dehydrated pigeonpeas were taken at random from each lot. The pigeonpeas with cracked or broken seedcoats were counted, the degree of cracking or breakage being recorded as to whether it affected less of more than half of the surface of the seed.

ORGANOLEPTIC APPRAISALS

A flavor-difference test was conducted in which two samples, one of treated and the other of untreated rehydrated pigeonpeas, were presented to a panel of experienced tasters in order to judge the difference in color, texture, and flavor. The tasters were seated in air-conditioned taste-booths under red light in order to mask the natural color of the pigeonpeas while scoring the flavor. The samples were moved out of the booth in order to score the color under natural light. In the scoring ballots the following questions were presented: Is there any difference and, if so, which sample do you consider has better color, flavor, and texture?

A preliminary flavor-acceptance test was also conducted under the conditions described above by using the Hedonic Scale in which 9 points were

given to the highest score indicating "like extremely" to 1 point for the lowest score indicating "dislike extremely". The data were analyzed statistically. The dehydrated pigenonpeas were also compared with canned pigeonpeas purchased from the local market which had been processed in Puerto Rico. All the pigeonpeas were presented to the tasters after being cooked with rice which constitutes a very popular dish in Puerto Rico. Therefore, a true picture might be obtained for the future consumption of this product.

TABLE 1.—*Moisture of dehydrated pigeonpeas as affected by chemical pretreatment*

Item	Pigeonpeas soaked in 0.2-percent solution of sodium hydroxide for 4 hours		Untreated pigeonpeas	
	Sample 1	Sample 2	Sample 1	Sample 2
Moisture as percentage of fresh peas	73.83	71.65	73.83	71.65
Weight in grams of fresh pigeonpeas before dehydration	7,710	9,072	7,710	9,072
Weight in grams gained in soaking	340	453	—	—
Weight in grams of pigeonpeas after rehydration	1,890	2,800	2,007	2,920
Moisture as percentage of dehydrated pigeonpeas	4.82	5.23	4.96	5.51
Weight in grams of 100 gm. of dehydrated peas after rehydration	360	320	338	292
Percentage rehydration	96.82	91.60	89.00	80.40
Gain in weight in grams, caused by soaking in 0.2-percent sodium hydroxide for 4 hours	340.0	450.0	—	—

The texture of the reconstituted pigeonpeas was determined by means of the shear press. The color was determined by means of the Hunter Color and Color Difference Meter.

CHEMICAL ANALYSES

The moisture content of the pigeonpeas was determined by means of drying in the vacuum oven. The protein was determined by the Kjeldahl method. The starch, total sugars, reducing sugars, and alcohol-insoluble solids were determined by the A.O.A.C. methods (*11*). All the analyses were made in duplicate and then averaged.

RESULTS AND DISCUSSION

The results of the moisture determination on the dehydrated pigeonpeas, shown in table 1, indicate that the pigeonpeas which were soaked for 4 hours in 0.2-percent solution of sodium hydroxide contained somewhat less

moisture than the untreated ones, regardless of their stage of maturity. However, the treated pigeonpeas gained weight from 4 to 6 percent during the soaking treatment; therefore more moisture was evaporated from them than from the untreated ones. This suggests that some changes, whether physical or chemical, might have occurred that made the pigeonpeas lose or absorb moisture easier and faster.

As indicated in table 2, more treated than untreated peas had broken seedcoats. This might have contributed to the acceleration of dehydration as well as rehydration.

RECONSTITUTION

The results shown in table 3 and figure 1, indicate that the treated pigeonpeas absorbed more moisture than the untreated ones at any length of rehydration time. The maximum weight for both treated and untreated

TABLE 2.—*The degree of breakage in the seedcoats of 500 dehydrated pigeonpeas as affected by chemical pretreatment*

Treatment	Seed without broken seedcoats			Seed with less than half the seedcoats broken			Seed with more than half the seedcoats broken		
	Range	Average	Percent	Range	Average	Percent	Range	Average	Percent
Seed soaked in 0.2-percent sodium hydroxide for 4 hours	—	—	0	10–21	16	3.2	479–490	484	96.8
Untreated seed	41.59	50	10	68–93	82	16.4	357–382	368	73.6

pigeonpeas was attained after 1 hour of simmering; it then remained almost constant up to 90 minutes. Here the treated pigeonpeas began to mash; the untreated pigeonpeas began to mash 10 minutes after the treated ones.

CHEMICAL ANALYSIS

The results of the chemical analyses obtained are shown in table 4. The protein contents are almost the same in both the treated and the untreated pigeonpeas, whereas the treated pigeonpeas contained more starch and less total sugars than the untreated ones. However, when adding the contents of the starch and the total sugars together, forming the major constituents of carbohydrates, the results indicate a drift of increment in the treated ones, as shown at the bottom of table 4. Histochemical research should be conducted in order to obtain sufficient data to explain these findings.

OBJECTIVE TEST FOR COLOR AND TEXTURE

The values of the shear press shown in table 5 indicate that a trend towards difference in the texture of the treated and the untreated pigeonpeas

TABLE 3.—*The weight in grams of 100 gm. of treated and untreated dehydrated pigeonpeas which were boiled and then simmered for different lengths of time*

Time simmered (minutes)	Weight of rehydrated treated pigeonpeas		Weight of rehydrated untreated pigeonpeas		Increment in weight due to treatment	
	Original moisture content 73.83 percent	Original moisture content 71.65 percent	Original moisture contents 73.83 percent	Original moisture content 71.65 percent	Original moisture content 73.83 percent	Original moisture content 71.65 percent
10	299	294	274	270	25	24
15	308	303	279	276	29	27
20	316	314	288	287	28	27
25	322	320	292	290	30	30
30	332	329	298	292	34	37
40	339	334	300	298	39	36
50	352	349	312	310	40	39
60	359	353	319	313	40	40
70	366	358	322	319	44	39
80	365	357	323	317	42	40
90	366	358	323	318	43	40

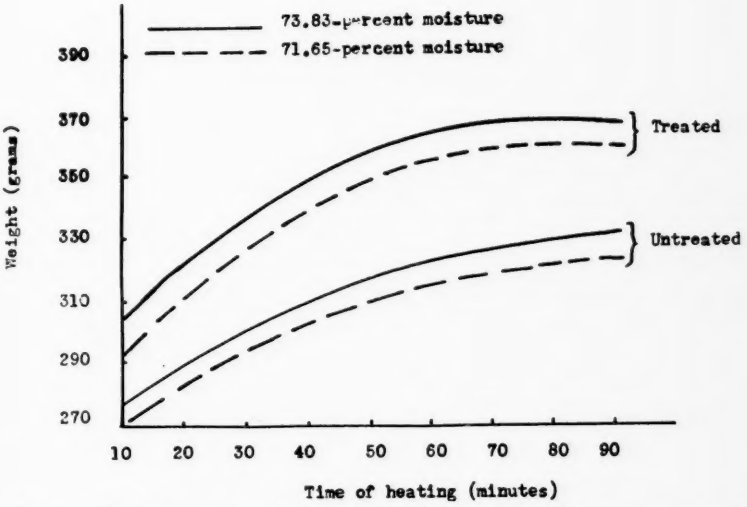

FIG. 1.—The increment in weight upon the rehydration of 100 gm. of treated and untreated pigeonpeas at different lengths of time.

exists. This corresponds with the scores of the majority of the judges during the organoleptic appraisals. The results for the color as determined by the Hunter Color and Color Difference Meter show that the treated pigeonpeas possess a rather greener color than the untreated ones. This also confirms

TABLE 4.—*Chemical analyses (percentage) of the treated and untreated dehydrated pigeonpeas of different moisture content*

Constituent	Treated				Untreated			
	Pigeonpeas with 73.83 percent original moisture		Pigeonpeas with 71.65 percent original moisture		Pigeonpeas with 73.83 percent original moisture		Pigeonpeas with 71.65 percent original moisture	
	Wet basis	Dry basis	Wet basis	Dry basis	Wet basis	Dry basis	Wet basis	Dry basis
Protein	20.59	21.63	19.67	20.70	20.57	21.70	19.28	20.40
Total sugars	1.68	1.77	2.22	2.33	2.42	2.55	2.34	2.47
Reducing sugars	0	0	0	0	0	0	0	0
Starch	53.46	56.16	58.31	61.35	50.76	53.56	55.69	58.93
Alcohol-insoluble solids	82.95	87.15	83.02	87.35	78.66	83.00	83.37	88.25
Starch + total sugars	55.14	57.93	60.53	63.68	53.18	56.11	58.03	61.40

TABLE 5.—*Values of the shear press and Hunter Color and Color Difference Meter for the rehydrated treated and untreated pigeonpeas of different moisture content*

Value	Treated pigeonpeas		Untreated pigeonpeas	
	Rehydrated peas with 73.83 percent original moisture	Rehydrated peas with 71.65 percent original moisture	Rehydrated peas with 73.83 percent original moisture	Rehydrated peas with 71.65 percent original moisture
Shear-press	360	560	520	760
Hunter Color and Color Difference Meter				
Rd	7.2	10.2	9.4	12.4
a	−2.5	−2.4	+.3	−.4
b	+13.3	+13.8	+13.2	+14.5

the scores by the majority of the tasters in judging the difference in the color.

ORGANOLEPTIC APPRAISAL

The results shown in table 6 indicate that a difference in the color and texture was definitely established, whereas no significant difference was shown in the flavor. This indicates that the treatment did not affect the

flavor as much as it did the color and texture. The majority of the judges preferred the color and texture of the treated pigeonpeas, but no significant difference could be established statistically, as shown in table 7. No preference was shown as to flavor as indicated in table 8.

TABLE 6.—*The scores of 10 judges indicating the difference in color, texture, and flavor between the treated and untreated pigeonpeas*

Characteristic	Is there any difference?		Which one do you consider has better color, texture, or flavor?			Minimum number of tasters required to have correct decision in paired tests for 1-percent levelsignificance
	Judges indicating yes[1]	Judges indicating no	Treated	Untreated	No difference	
Color	10*	0	7	3	0	10
Texture	10*	0	6	4	0	10
Flavor	8	2	4	4	2	10

[1] * Significant difference at the 1-percent level.

TABLE 7.—*The analysis of variance of the scores of 15 tasters, indicating the degree of acceptability of the treated and untreated dehydrated pigeonpeas when cooked with rice*

Source of variance	Degrees of freedom	Sum of squares	Mean squares	*F*	*F* at 5-percent level
Among treatments	1	0.3	0.3	0.491	4.21
Among scores of tasters	28	17.1	.61		
Total	29	17.4			

TABLE 8.—*The analysis of variance of 10 tasters, indicating the degree of acceptance of the treated, untreated, and canned pigeonpeas when cooked with rice*

Source of variance	Degrees of freedom	Sum of squares	Mean squares	*F*	*F* at 5-percent level
Among treatments	2	1.27	0.63	0.50	3.53
Among scores of tasters	27	33.70	1.24		
Total	29	34.97			

SUMMARY

A study was undertaken to determine the effect of soaking pigeonpeas in a 0.2-percent solution of sodium hydroxide for 4 hours before dehydration, upon the quality of the dehydrated product. The results showed that:

1. The treated pigeonpeas contained less moisture, but had a higher

rehydration ratio upon reconstitution than the untreated ones, regardless of their stage of maturity.

2. The percentage of breakage in the seedcoats of the treated pigeonpeas was higher than that for the untreated ones.

3. The protein content was almost the same in the treated and untreated peas, but the treated pigeonpeas were higher in starch and lower in total sugars than the untreated ones.

4. The organoleptic tests established a definite difference in color and texture between the products, but no difference in flavor. The two products were equally acceptable to the taste panel. Similar results were obtained when comparing both treated and untreated dehydrated pigeonpeas with the canned ones.

5. The shear-press and the Hunter Color and Color Difference Meter tests indicated that the treated pigeonpeas were more tender and greener than the untreated ones.

RESUMEN

Se llevó a cabo un estudio para determinar los efectos que ha de tener sobre la calidad de los gandures secos el empaparlos en una solución de hidróxido de sodio al 0.2 por ciento durante cuatro horas antes de deshidratarlos. Los resultados demonstraron lo siguiente:

1. La humedad de las gandures tratados fue más baja que en los que no se trataron. Al reconstituirse, absorbieron más agua irrespectivamente de su grado de madurez.

2. El porcentaje de cutícula rota fue mayor en los gandures tratados que en los que no se trataron.

3. El contenido de proteínas no fue alterado por el tratamiento. Los gandures tratados contenían mas almidón y menos azúcares totales que los que no se trataron.

4. Las pruebas de catado establecieron una destacada diferencia en cuanto a color y textura de ambos productos, aunque no se notó diferencia alguna en el sabor. Los dos productos tuvieron el mismo grado de aceptación por el panel de catado. Cuando se compararon ambos productos deshidratados con los enlatados se obtuvieron resultados similares.

5. Las pruebas de dureza, color y diferencia de color demonstraron que los gandures tratados quedaron más tiernos y mas verdes que los que no se trataron.

LITERATURE CITED

1. Sánchez-Nieva, F., The Canning of Pigeonpeas, Master Plans, Department of Food Technology, Agr. Exp. Sta., Project Hatch 70, fiscal year 1959–60.
2. Litwiller, E. M., and Pettit, L. A., Dehydrated Blue Lake green beans, *Food Tech.* **11** 229–31, 1957.

3. Hand, D. B., Moyer, J. C., and Wagenknecht, A. C., Effect of drying conditions on moisture retention and density of dehydrated peas, *Food Tech.* **9** 222, 1955.
4. Talburt, W. F., and Legult, R. R., Dehydro-frozen peas, *Food Tech.* **4** 286–91, 1950.
5. Rahman, A. R., Histological and Histochemical Investigations of the Effect of Certain Chemicals Upon the Quality of Dehydrated Peas, Ph.D. thesis, Oregon State College, Corvallis, Oreg., 1956.
6. Cruess, W. V., Commercial Fruit and Vegetable Products, 3d ed. p. 906, McGraw-Hill, New York, N.Y., 1948.
7. Dawson, E. M., Batchelder, E. L., and Taube, K. R., Flavor, Texture, Color, and Ascorbic Acid Content of Home Dehydrated Vegetables and Fruits, p. 68, USDA Tech. Bul. 997, Washington, U.S. Government Printing Office, 1950.
8. Blair, J. S. and Ayres, T. B., Protection of natural green color pigment in the canning of peas, *Ind. Eng. Chem.* **35** 85, 1943.
9. Gieseker, L. F., Preserving the Color of Canned Peas, U.S. Patent 2,473,747, June 21, 1949.
10. Moyer, J. C., Nutritive value of dehydrated vegetables, *J. Amer. Diet. Assn.* **19** 13–7, 1943.
11. Assn. of Agr. Chem., Official Methods of Analysis, Washington, D.C., 8th ed., 1955.
12. Lloréns, Antonio A., Olivieri, José A., and Ríos, J. M., Production and Marketing of Pigeon Peas in Puerto Rico, E. & R. S. 32, Univ. P.R., Agr. Exp. Sta., 1956.
13. Von Loeseke, M. W., p. 98–102, Drying and Dehydration of Foods, Reinhold, New York, N.Y., 1955.
14. Statistical Yearbook 1958, Bureau of Economics and Statistics, Puerto Rico Planning Board.

Effects of Scarification and Gibberellic Acid on Germination of Congo Watermelon Seed[1]

Agripino Pérez López[2]

INTRODUCTION

Watermelon (*Citrullus vulgaris* L.) is gaining great commercial importance in Puerto Rico because it can be grown during practically the entire year. This makes possible the production of watermelons for the winter markets when the competition with fruit produced in the Temperate Zone countries is at a minimum.

At present the introduction of seedless watermelon varieties appears to be promising since they are doing very well under our conditions. Because of the high cost of the seed of the seedless watermelon, germination studies are being performed in an attempt to insure optimum utilization of the seed available.

The work of Zielinski (*3*),[3] who found that notching cherry seed increased germination, and of Paine (*1*), who reported that the germination of hop seed might be more than doubled by removal of the operculum, and the studies reported for different economic crops by Wittwer and Bukovac (*2*) suggested that scarification and gibberellic acid might hasten and increase watermelon seed germination. This work was therefore undertaken to determine the usefulness of scarification and gibberellic acid in the germination of Congo watermelon seed.

MATERIALS AND METHODS

The seed were treated in the following manner:

SCARIFICATION TREATMENT

One hundred and twenty seed were used for each treatment of those shown in figure 1. A file was gently passed over each individual seed from 5 to 10 times.

GIBBERELLIC ACID TREATMENTS

Each group of 120 seed that received the scarification treatment was divided into three groups of 10 seed replicated 4 times for treatment with gibberellic acid. The seed not treated with gibberellic acid were not soaked

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[3] Italic numbers in parentheses refer to Literature Cited, p. 187.

in water, but the other two groups were soaked for 52 hours in water containing 50 and 100 p.p.m. (parts per million) of the acid.

The seed were sown on previously fumigated metal flats containing a mixture of soil of the Coto sandy clay type and filter-press cake (*cachaza*) at the ratio of 1 to 1. The sown flats were exposed in the open.

The seed germination was counted 7, 8, 10, and 14 days after sowing.

RESULTS

SEVEN DAYS AFTER SOWING

Scarification Treatments

None of the scarification treatments was statistically superior to the check. These results were found during all the four germination countings. This indicates that it does not pay to scarify the seed before sowing them.

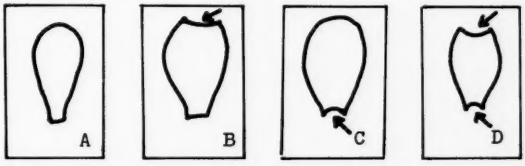

FIG. 1.—Diagram illustrating the watermelon seed and its treatments: A, Check; no scarification. B, Scarification of the wider end of the seed. C, Scarification of the narrower end of the seed. D, Scarification of both ends of the seed. The arrows point to the scarified ends of the seed enlarged two times.

Gibberellic Acid Treatments

The increase of gibberellic acid from 0 to 100 p.p.m. reduced the germination of Congo watermelon seed in a highly significant way. The reduction in germination of the seed treated with 50 p.p.m. of the acid was significant only at the 5-percent level. The mean percentages of seed germinated for the 0, 50, and 100 p.p.m. of gibberellic acid were 62.50, 55.00, and 40.00, respectively (table 1 and figure 2).

The standard errors and least differences required for significance between mean percentage of germinated seed under gibberellic acid treatments are shown in the following tabulation:

Comparison	*5-percent level*	*1-percent level*
Least significant difference between highest and lowest means	14.16	18.03
Least significant difference between 2 adjacents	11.75	15.79

Standard error 4.08 with 16 d.f.

EIGHT DAYS AFTER SOWING

Gibberellic Acid Treatments

Table 1 shows the mean percentages for seed germination. Figure 2 also shows graphically the differences between treatments. Seed receiving 0 and 50 p.p.m. of gibberellic acid germinated highly significantly more than those receiving 100 p.p.m. of the chemical. The difference between 0 and 50 p.p.m. was significant only at the 5-percent level. The mean percentages of germination for the seed receiving 0, 50, and 100 p.p.m. of gibberellic acid were 77.50, 67.50, and 53.13, respectively.

The standard errors and least differences required for significance be-

TABLE 1.—*The effects of 3 concentrations of gibberellic acid on the mean germination percentage of Congo watermelon seed 7, 8, 10, and 14 days after being sown*

Concentrations of gibberellic acid (p.p.m.)	Germinated seed after number of days indicated				Mean
	7	8	10	14	
0	62.50	77.50	78.13	76.88	74.38
50	55.00	67.50	70.00	70.63	65.78
100	40.00	53.13	53.75	55.63	50.63
Mean	53.33	66.04	67.29	67.71	63.59

tween mean percentage of germinated seed of those treated with gibberellic acid are shown in the following tabulation:

Comparison	*5-percent level*	*1-percent level*
Least significant difference between highest and lowest means	12.67	16.13
Least significant difference between 2 adjacents	10.51	14.13

Standard error 3.65 with 16 d.f.

TEN DAYS AFTER SOWING

Gibberellic Acid Treatments

The mean percentages of germinated seed are presented in table 1 and figure 2. For the concentrations of 0, 50, and 100 p.p.m. of gibberellic acid the germination percentages were 78.13, 70.00, and 53.75, respectively. The means for 0 and 50 p.p.m. of gibberellic acid were highly significantly greater than the mean for 100 p.p.m. of the chemical. The difference between 0 and 50 p.p.m. was not significant. In this case, as in the 7- and 8-day samples after sowing the seed, the gibberellic acid application suppressed the germi-

nation of the Congo watermelon seed. The suppression increased as the concentration of the gibberellic acid increased.

The standard errors and least differences required for significance between

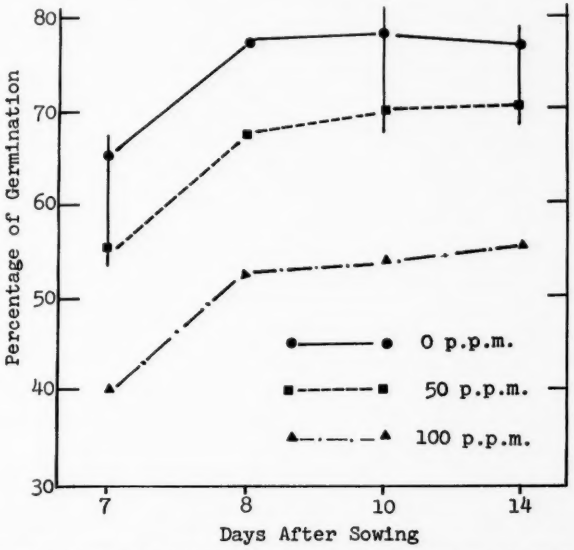

FIG. 2.—The effects of 3 concentrations of gibberellic acid on the germination of Congo watermelon seed. Means enclosed by the same vertical line are not significant at the 5-percent level; means not enclosed by the same vertical line are significant at the 5-percent level or more.

mean percentage of germinated seeds under gibberellic acid treatment are shown in the following tabulation:

Comparison	*5-percent level*	*1-percent level*
Least significant difference between highest and lowest means	11.66	14.85
Least significant difference between 2 adjacents	9.68	13.0

Standard error 3.36 with 16 d.f.

FOURTEEN DAYS AFTER SOWING

Gibberellic Acid Treatments

The means for the gibberellic acid-treated seed (table 1 and figure 2) were 76.88, 70.63, and 55.63 for the 0, 50, and 100 p.p.m., respectively. In the treatments receiving 0 and 50 p.p.m. of gibberellic acid the germination

percentage was highly significantly greater than in those receiving 100 p.p.m. The difference between 0 and 50 p.p.m. of gibberellic acid was not significant. On this date, as on the previous three, the gibberellic acid reduced the germination. This reduction tended to increase as the concentration of the chemical increased.

The standard errors and least differences required for significance between mean percentage of germinated seed of those treated with gibberellic acid are shown in the following tabulation:

Comparison	*5-percent level*	*1-percent level*
Least significant difference between highest and lowest means	11.10	14.14
Least significant difference between 2 adjacents	9.22	12.38

Standard error 3.20 with 16 d.f.

DISCUSSION

This study demonstrated that none of the scarification treatments was statistically superior to the check. This same result was found during all the four germination countings. This tends to indicate that there is no need to scarify Congo watermelon seed because the humidity enters readily through the seedcoats after sowing.

The experiment also showed that gibberellic acid should not be used to promote the germination of watermelon seed, at least with Congo, the variety used in this study, because it reduces germination. This reduction in germination was increased as the concentration of the acid increased, irrespective of the scarification treatments given to the seed. As had been reported (*2*), and in accordance with the results of this study, gibberellic acid may promote the germination of seed that require a dormancy period, but not of those which do not require it, such as the watermelon.

The interaction between scarification and gibberellic acid was not significant. This indicates that there is no need to scarify the seed and then soak them in a solution of the acid because this acid reduces germination of scarified as well as of nonscarified seed.

SUMMARY

The effects of scarification and the use of gibberellic acid were studied on the germination of Congo watermelon seed observed in the germinating flats 7, 8, 10, and 14 days after sowing. Observations were made on the percentage of germinated seeds. The major results were as follows:

1. Gibberellic acid at concentrations of 50 and 100 p.p.m. considerably reduced the germination of the watermelon seed. This effect was observed on all four dates that the germination was counted. The reduction in germination increased as the concentration of the gibberellic acid increased.

2. None of the scarification treatments was statistically superior to the check. This was found at all four germination countings.

RESUMEN

Se estudió el efecto de la escarificación y el uso del ácido giberélico en cuanto a la germinación de la semilla de sandía. Los resultados fueron los siguientes:

1. El ácido giberélico, en concentración de 50 y 100 p.p.m. (partes por millón), redujo considerablemente el porcentaje de germinación de la semilla de sandía. Este efecto se observó durante cada una de las cuatro fechas en que se contaron las semillas germinadas. La reducción en la germinación aumentó al aumentar la concentración del ácido giberélico.

2. Ninguno de los tratamientos usados para escarificar la semilla demostró ser estadísticamente superior al testigo. Este efecto se observó en cada una de las cuatro fechas en que se contaron las semillas germinadas.

LITERATURE CITED

1. Paine, J., The Treatment of Hop Seed to Improve Germination, East Malling Res. Exp. Sta., England, Ann. Rep. 139–40, 1950.
2. Wittwer, S. H., and Bukovac, M. J., The effects of gibberellin on economic crops, *Econ. Bot.*, **12** 213–55, 1958.
3. Zielinski, Quentin B., Some factors affecting seed germination in sweet cherries, *Proc. Amer. Soc. Hort. Sci.* **72** 123–9, 1958.

Effects of Gibberellic Acid on Germination of Papaya (*Carica papaya* L.) Seed

Oscar D. Ramírez[1]

INTRODUCTION

The papaya (*Carica papaya* L.) is a well-known and popular fruit in many parts of the world. It is pleasing to taste both as fresh or preserved fruit and is popularly considered medicinal.

Papaya seed germination is rather irregular. Alonso-Olivé (*1*)[2] reported that the germination of the papaya seed usually starts from 2 to 3 weeks after planting and sometimes even later. This slow germination rate is a handicap in the production of this fruit. Since gibberellic acid has been used successfully (*2*) to accelerate seed germination of various other crops, studies were conducted to investigate the possibility of utilizing it in accelerating papaya seed germination.

This paper reports the results of the preliminary studies conducted at this Station using various concentrations of gibberellic acid to determine its effect on papaya seed germination.

MATERIALS AND METHODS

Seed were obtained from a red-flesh papaya fruit and treated (fig. 1) with a proprietary product (*3*) containing 0.88 percent of potassium gibberellate. The dosages used were 0, 2.50, 5.00, 7.54, and 10.00 mg. of the above-mentioned product per 2 gm. of seed. Seed and chemical were shaken together in a glass jar so that the chemical would adhere to the seedcoat.

After treatment the seed were planted in flats in the greenhouse. A 5 x 5 Latin-square design was used and 15 seed were sown in each plot. Daily germination records were taken for a period of 31 days.

RESULTS AND DISCUSSION

EFFECT OF GIBBERELLIC ACID ON THE TIME OF GERMINATION

The results obtained as to the effect of gibberellic acid on the time of germination are presented in the following tabulation:

Dosage in milligram	*Mean days for germination*
0	17.98
2.50	19.15
5.00	17.34
7.54	18.53
10.00	17.66

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[2] Italic numbers in parentheses refer to Literature Cited, p. 190.

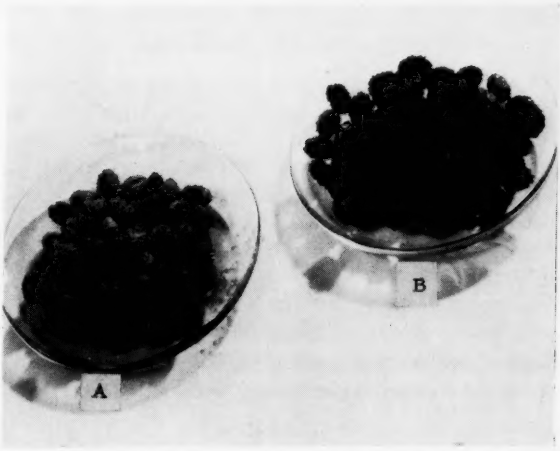

FIG. 1.—A, Papaya seed after treatment with Gibrel, a proprietary containing 0.88 percent of potassium gibberellate; B, untreated seed for comparison.

The standard error and least differences required for significance between means are shown below:

Item	*5 percent*	*1 percent*
Difference between highest and lowest	2.11	2.73
Difference between highest and 2nd lowest	1.96	2.57
Difference between highest and 3d lowest	1.76	2.36
Difference between highest and 4th lowest	1.44	2.02
Standard error of a mean: 0.469, with 12 d.f.		

The results obtained show that the treatment of papaya seed with gibberellic acid is not effective in accelerating its germination. No significant differences were found in the germination rate of papaya seed as affected by the different dosages of gibberellic acid.

TABLE 1.—*Effect of gibberellic acid on the germination percentage of papaya seed*

Dosage (milligrams)	Seed per plot	Seed per treatment	Mean number of seed germinated	Germination
	Number	*Number*	*Number*	*Percent*
0	15	75	12.60	84.00
2.50	15	75	12.20	81.33
5.00	15	75	12.40	82.66
7.54	15	75	12.00	80.00
10.00	15	75	11.60	77.33

EFFECT OF GIBBERELLIC ACID ON THE GERMINATION PERCENTAGE OF PAPAYA SEED

The effect of gibberellic acid on the germination percentage is shown in table 1. The standard error and least differences required for significances between means in table 1 are shown in the following tabulation:

Item	*5 percent*	*1 percent*
Difference between highest and lowest	4.35	5.64
Difference between highest and 2nd lowest	4.05	5.31
Difference between highest and 3d lowest	3.64	4.86
Difference between highest and 4th lowest	2.97	4.17

Standard error of a mean: 0.966, with 12 d.f.

The data show that the dosages of gibberellic acid used had no significant influence on seed germination percentage.

SUMMARY

Papaya seed were treated with the potassium salt of gibberellic acid to determine the effect on the time interval and percentage of germination. The dosages used were 0, 2, 4, 6, and 8 ounces of 0.88 percent of potassium gibberellate per 100 pounds of seed.

No significant effect was observed in accelerating the germination of papaya seed nor on the germination percentage.

RESUMEN

Se trató semilla de papaya con la sal de potasio del ácido giberélico para determinar si era posible acelerar el tiempo normalmente requerido para la germinación, o si éste tenía alguna influencia sobre el porcentaje de su germinación.

Se usaron 5 tratamientos, a saber: 0, 2, 4, 6 y 8 onzas de giberelato de potasio al 0.88 por ciento por cada 100 libras de semilla.

No se encontró diferencia significativa alguna en cuanto al tiempo de germinación de la semilla como resultado de los tratamientos. Tampoco se encontró diferencia significativa en cuanto al porcentaje de germinación como resultado de los diferentes tratamientos con ácido giberélico.

LITERATURE CITED

1. Alonso-Olivé, R. E., Observaciones sobre el Cultivo y Mejoramiento del la Fruta Bomba, Bul. 67, Est. Exp. Agr. Santiago de las Vegas, La Habana, Cuba, 1952.
2. Witter, S. H., and Bukovac, M. J., Gibberillin and higher plants: VII Seed treatments for beans, peas, and sweet corn, Mich. State Univ. Agr. Exp. Sta. *Quart. Bul.* **40**(1) 215–24, 1957.
3. Gibrel (Brand Plant Growth Substance) Monograph (1–67 pp.) Merck and Co. Inc., Chem. Div., Rahway, N.J.

RESEARCH NOTES

DELETERIOUS EFFECT OF SIMAZINE ON MOSAIC-INFECTED SUGARCANE

Because of the increased cost it is now almost prohibitive to use manual labor for the control of weeds in growing many crops. This is especially true in the cultivation of sugarcane. More than 90 percent of the chemicals consumed in weed control in Puerto Rico are used in the cultivation of this crop.

When properly handled and applied, the weedicides recommended for use in the Island have no injurious effect on the germination and development of the cane plant. We want to report an interesting observation made in the course of routine applications of the herbicide Simazine (2-chloro 4, 6 bis-ethylamine) *s*-triazine to control weeds in cane grown for experimental purposes.

No injurious effects were noticed when the herbicide was applied in solution, at a rate of 1 pound per acre, to healthy cane varieties, either as a pre-emergent or postemergent treatment. However, when Simazine was applied at the same concentration to mosaic infected canes of variety B.34104, growing in flats in the laboratory, a remarkable effect became apparent, consisting of an intensification of the already present chlorosis, stuntiness, lodging, and basal stem rot of the plants. No such effect was observed in the nontreated mosaic-infected plants.

As far as we know this is the first time that such an effect of a herbicide on mosaic-infected sugarcane plants has been reported. Taking into consideration the facts that Simazine, as well as other herbicides such as CMU, are being used increasingly in the control of weeds in our sugarcane fields, and that we still have a large acreage of mosaic-infected canes such as B.37161 in the Island, we consider it of interest to publish this preliminary note. Experiments are in progress to study further the effects of Simazine as well as of other herbicides on mosaic-infected canes.

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THE ABSORPTION OF WATER BY WASHED PARCHMENT COFFEE WHEN STORED UNDER WATER

It has been observed that it is a common practice among coffee processors of Puerto Rico during peak harvest periods, when existing drying facilities prove inadequate, to store fermented washed parchment coffee under water for periods of up to 48 hours to prevent it from deteriorating. This investiga-

tion was undertaken to determine whether there was appreciable absorption of water by the parchment coffee during such periods of submergence.

Small replicated samples of fermented washed parchment coffee were placed in tared baskets of fine meshed screen which were suspended in beakers of water. The basket and the parchment coffee were initially placed in the beakers for 2 minutes. They were then removed and 2 minutes were allowed for the unattached free water to drain from the parchment coffee, after which the initial weight of the basket and parchment coffee was ascertained. The basket with the parchment coffee was again suspended in the beaker of water and reweighed at intervals of 1, 4, 12, 24, 48, and 72 hours, a period of 2 minutes being allowed for the drainage of the free water from the basket before each weighing.

The recorded net mean weights of the samples of parchment coffee at the stated intervals reduced to a percentage basis of the initial weight are shown in the following tabulation:

Period in hours	*Percentage of initial weight*	*Difference from previous value*
0	100.00	—
1	101.24	1.24
4	101.40	.16
12	100.65	−.75
24	100.41	−.24
48	100.95	.54
72	101.34	.39

A statistical consideration of the results shows that a difference from the previous value of the "percentage initial weight" greater than 0.95 is significant at the 5-percent probability level, or of 1.40 at the 1-percent probability level; therefore, there is a significant increase in weight at the 5-percent level only after the first hour of soaking. Subsequent periods of soaking reveal no further significant increases, and the slight variations from period to period may be attributed to experimental error.

The samples did not appear to deteriorate during the 72 hours of submergence; however, it will be necessary to undertake further investigations to ascertain whether the cup quality of the coffee is in any way impaired by such treatment or if the change in weight is due to factors other than water absorption.

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CONTROL OF BACTERIAL WILT OF TOMATO BY STREPTOMYCIN IN A HYDROPONIC FARM[1]

During the month of November 1953 a sudden outbreak of bacterial wilt was observed in a 2-acre tomato hydroponic farm of the Land Authority at Vega Alta, P. R. The hydroponic installation consisted of two sections each with a capacity of 26,000 gallons of nutrient solution. Each unit consisted of 30 beds, each bed holding approximately 300 plants. Symptoms of typical bacterial wilt were first observed in one bed where approximately 8 percent of the plants were affected. Several of the diseased plants were uprooted and brought to the Plant Pathology Department for bacteriological study.

From stem pieces which showed brown discoloration of vascular tissue as well as from the ooze exuded by pieces of cut stems placed in water, pure cultures of a highly motile, gram-negative bacillus were obtained. The isolated bacterium was subsequently identified as *Pseudomonas solanacearum* E.F.S. Because of the special conditions in a hydroponic farm in which the infectious agent may be rapidly spread from diseased to healthy plants through the nutrient solution, rapid measures for identification and control had to be taken. Since broth cultures were available, sensitivity tests with antibiotic discs (Difco)[2] were performed by seeding nutrient agar plates with 24-hour-old broth cultures.

Results of the sensitivity test showed that the bacterium was susceptible *in vitro* to a concentration of 1 μg. of streptomycin, being therefore very sensitive to the antibiotic. On this basis a recommendation was made to apply streptomycin sulfate directly to the main tank of the nutrient solution of the affected section so that a final concentration of approximately 4 μg. of streptomycin per milliliter would be reached. At the same time the more heavily affected plants were removed and only those showing slight wilting effects (one or two wilted leaves) were left. In a few days the slightly wilted plants recovered completely and no more cases appeared. A second dose of streptomycin was given the following week so as to insure complete recovery in the affected section.

The success of streptomycin treatment in this particular outbreak is believed to have been due to the fast action taken. The application of streptomycin directly to the tank of nutrient solution made the antibiotic

[1] The observations recorded here were made in 1953, but had not been reported before because circumstances prohibited the completion of a larger, planned, experimental study.

[2] Difco Manual of Dehydrated Culture Media and Reagents, 9th ed.—Difco Laboratories, Detroit 1, Mich.

rapidly available to all the tomato plants in the hydroponic section affected by bacterial wilt. The disease was controlled in plants already showing symptoms of wilt and healthy plants were presumably protected from becoming infected *via* the solution.

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CONTROL OF NEMATODES ATTACKING SUGARCANE

The Department of Entomology (Section of Nematology) of the Agricultural Experiment Station, has been studying the most economical and efficient means of controlling the nematodes that attack the roots of sugarcane. Nematological studies in the sugarcane fields of Puerto Rico indicate that the most common and important plant-parasitic nematodes found are the following: Spiral nematodes, *Helicotylenchus* spp.; reniform nematodes, *Rotylenchulus* spp.; stylet nematodes, *Tylenchorhynchus* spp.; meadow nematodes, *Pratylenchus* spp.; ring nematodes, *Criconemoides* and *Hemicriconemoides* spp.; and root-knot nematodes, *Meloidogyne* spp. Other nematodes also occurring in sugarcane but less common are: *Hoplolaimus*, *Paratylenchus*, *Aphelenchoides*, *Criconema*, *Tylenchus*, *Ditylenchus*, *Trichodorus*, *Xiphinema*, and *Longidorus*.

Presently the methods most commonly used for the control of these parasites are complicated and often difficult to use. A thorough preparation of the soil, favorable weather and moisture conditions, a waiting period between fumigation and planting, and so on, are some of the conditions normally to be met for successful control. But with emulsifiable soil fumigants such as Nemagon and Fumazone, the attainment of these conditions is less necessary.

A number of experimental tests were made at the south coast of the Island to determine the effect of Nemagon on the germination of sugarcane. It was found that an application of one-half gallon per acre of concentrated Nemagon incorporated into the irrigation water increased the germination of the sugarcane seed by 50 percent, and the overall plant height by an average of 10 cm.

Now an experiment has been set up at the Isabela Substation to determine the nematocidal effectiveness of Nemagon and Fumazone and their final effect on the yield of sugar of variety PR. 1013. Both nematocides were applied in the irrigation water at the rates of ½ gallon and 1 gallon of concentrate per acre, using a Jaeco Gravity-Flow Fumigating Kit[1] (see fig. 1.). The treatments were replicated six times. Control plots received water only.

[1] The kit was obtained from the Joaquin Agricultural & Engineering Co. Inc., Box 150, Hanford, Calif.

Statistical analysis of the nematode populations before and after fumigation indicated that all treatments were significantly better in reducing the

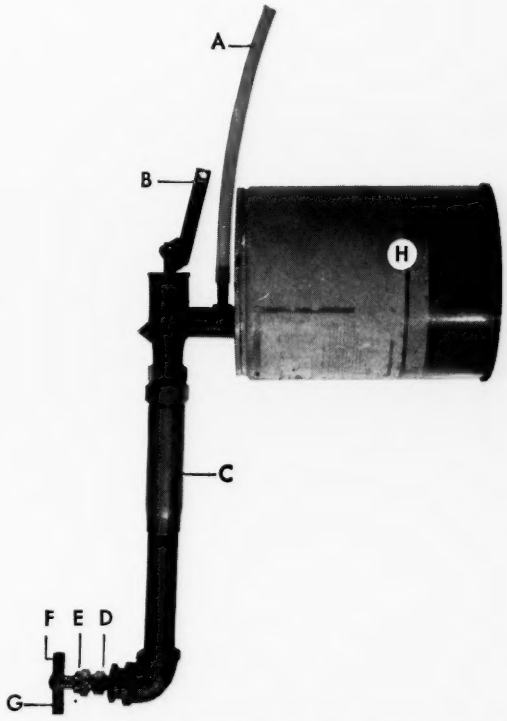

FIG. 1.—Jaeco gravity-flow fumigating kit: A, First air-intake tube; B, level of the valve that starts outflow; C, first impurity-retaining screen (inside tube); D, second impurity-retaining screen (inside tube); E, graduated orifice (inside tube); F, second air-intake tube; G, outflow point; H, chemical container.

number of nematodes when compared to the control. However, no significant differences were found between the nematocidal treatments.

Results of this experiment will be published when complete data are available.

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AGRICULTURAL EXPERIMENT STATION

(*Continued from inside front cover*)

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